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PROJECT MERCURY
FIRST INTERIM REPORT

STAFF REPORT

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS
U.S. HOUSE OF REPRESENTATIVES

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JANUARY 27, 1960.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

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LETTER OF SUBMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., January 27, 1960.

Hon. SAM RAYBURN,
Speaker of the House of Representatives,
Washington, D.C.

DEAR MR. SPEAKER: By direction of the Committee on Science and Astronautics, I submit the following report, approved by the committee, of a staff study.

The findings and conclusions are offered to the 86th Congress for consideration.

OVERTON BROOKS, *Chairman.*

LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., January 15, 1960.

Hon. OVERTON BROOKS,
Chairman, Committee on Science and Astronautics.

DEAR MR. CHAIRMAN: There is forwarded herewith for your consideration and submittal to the Congress a staff report, "Project Mercury, First Interim Report."

This report, on the United States most prominent space program, has been prepared as an aid to the Congress for the forthcoming session. The report covers the background of the activities that led to Project Mercury, and the details of the capsule design, components, and subsystems. Included is a description of the operational concept, the Astronaut program, project management, funding, and schedule. Several conclusions were reached regarding the overall status of the program.

The report was prepared by Lt. Col. Francis J. Dillon, Jr., staff consultant. He was assisted by Mr. John A. Carstarphen, Jr., chief clerk. The report was reviewed by members of the professional staff.

There have been suggestions that the committee should undertake a thorough investigation of all the decisions and history of Project Mercury. It should be made clear that the enclosed study is not of that nature, and was designed for another purpose—that of general background and information on the program, based almost exclusively on official materials prepared in the National Aeronautics and Space Administration. These reports, statements, and budgetary and management documents were used principally in parts II through IX, adapted to fit the needs of this report, and also were used in conjunction with other material to prepare part I. Assistance and information, provided by the Office of the Secretary of Defense and the three services, was also used in preparing parts I and X. Part XI was prepared exclusively by this staff, and represents conclusions based largely upon the materials available in the report, rather than representing any definitive judgments on Project Mercury.

CHARLES F. DUCANDER,
Executive Director and Chief Counsel.

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JANUARY 27, 1960.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

Mr. BROOKS of Louisiana, from the Committee on Science and Astronautics, submitted the following

REPORT

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PROJECT MERCURY

PART I

BACKGROUND

Importance

"One of the most significant milestones in the history of space flight will be the first successful launching, flight, and recovery of a man from space. The event will be of such importance that it cannot fail to earn worldwide acclaim for the technical skill of the nation first accomplishing this difficult task.

"Project Mercury, the current manned space flight program of the NASA, represents this Nation's effort to place a man in space. The project was conceived and is being carried out in a manner that will attempt to achieve the earliest possible space flight by man. It will use developed booster systems through all phases of the program. The space capsule, the actual flight vehicle, is based upon design principles that require no major technological breakthroughs for successful accomplishment.

"Even though we in the United States apply our greatest effort to this problem we must recognize that we may lose the psychological battle to be first. We cannot place prestige above life. A fundamental concept of Project Mercury is that the safe return of the astronaut must be assured. Other nations having less regard for human life may shortcut the development procedures that we think essential and may thereby accomplish manned space flight before we do.

"Although we in the United States have no certain knowledge of the desires and intentions of other countries to be the first to achieve manned space flight, we cannot relax our own efforts in the hope that others will do likewise. To do so and be wrong would make certain a psychological defeat for the United States in the eyes of the world."[1]

Urgency of Project Mercury

Project Mercury is now being developed by the National Aeronautics and Space Administration with the utmost sense of urgency. The Administrator of NASA has declared that this project is the most urgent of all NASA projects.

Project Mercury has been endorsed by the National Aeronautics and Space Council, and approved by the President, as a program of top national priority. Consequently it carries a DX priority rating.

Stages of manned flight

From time immemorial man has dreamed of extending his range of operation above the surface of the earth. Tied to a two-dimen-

[1] Testimony of Dr. Hugh Dryden before the House Science and Astronautics Committee on 1960 NASA authorizations, April 24, 1959.

sional world he yearned to extend his knowledge of the universe beyond the earth just as he discovered new lands beyond the seas.

Now that he stands on the threshold of manned flight into space he can look back to the various stages that have brought him to this accomplishment. Balloons were used as the first method of sustained flight, then gliders, and eventually powered aircraft. Man gradually extended his flying capability by going ever higher, faster and farther with winged vehicles using various types of propulsion such as reciprocating, jet and rocket engines. The rocket was known long before the other engines, but using it for manned ballistic or orbital flight was not considered practical until large boosters became available.

Now, man has sent his instruments into space, establishing new satellites in orbit around the earth and new planets of the sun. In these preliminary steps in the penetration of space, two major methods of conducting manned space flight have been considered: the winged, or high-lift vehicle, and the ballistic capsule, or zero-lift vehicle. Vehicle configurations with varying degrees of lift have also been investigated. Research, accordingly, has proceeded along both lines in Government agencies and industries interested in these types of problems and has resulted in the development of rocket boosters capable of lifting large payloads to orbital altitudes and velocities. These boosters, designed primarily for the ballistic missile program, can in turn provide the propulsion systems for man's higher, faster, and farther flight.

In research projects aimed at the development of manned rocket aircraft using winged vehicles, the National Advisory Committee for Aeronautics (NACA), the predecessor to the National Aeronautics and Space Administration (NASA), assisted the military services and the aircraft industry in carrying on studies of manned flight through the ranges of speed, altitude, and distance. The NACA participated in the first U.S. manned rocket aircraft programs which have since led to the X–15, a hypersonic vehicle which will soon depart the earth's atmosphere and operate in the vacuum of space for a few minutes, though not at orbital speeds. Manned space flight in winged vehicles will continue because of the benefits that are afforded during controlled reentry and landing.

On the other hand, project Mercury, the first major program concerned with the lowlift vehicle approach, will use the ballistic capsule. The reasons are that U.S. technology has advanced to the point where many of the problems of ballistic-type reentry have been solved and because the propulsion system is now available to boost the lighter ballistic capsule to orbital velocity.

Origin of program

It is difficult to state when the manned orbital flight program began in the United States. A review of the historical background shows that the Air Force, in March 1956, initiated Project 7969, entitled "Manned Ballistic Rocket Research System," with the specific task of recovering a manned capsule from orbital conditions. By December of that year, proposals for study were received from two companies to conduct this research. Due to lack of funds, the Air Force conducted some inhouse studies and requested those industrial organizations showing interest to finance research studies with their cor-

porate funds. By January 1958, seven firm proposals from industry to develop an orbital vehicle were received by the Air Force. With the help of the National Advisory Committee for Aeronautics, the technical evaluation of all concepts was initiated.

During this same period NACA staff members were studying the possibilities of utilizing ballistic missile boosters to provide the velocities and altitudes required for manned orbital and space flight. During 1957 and 1958 these studies were intensified.

In a formal letter to the Director of the NACA on January 31, 1958, the Air Force invited NACA participation in the U.S. Air Force planned development program in a manner similar to the arrangement made for the X–15 hypersonic test aircraft development. This agreement was signed by the Director of NACA on April 11, 1958.

The first official instructions received by the Air Force for the manned satellite program were from the Advanced Research Projects Agency (ARPA) of the Office of the Secretary of Defense. The memorandum to the Secretary of the Air Force, on February 28, 1958, stated in part that ARPA "recognized the Air Force has a long-term development responsibility for manned space flight capability, with the primary objective of accomplishing satellite flight as soon as technology permits." The memorandum further "authorized development of a test vehicle for experimental flights with laboratory animals, in furtherance of the objective of manned satellite flight."

In March 1958, a working committee of personnel from the NACA Langley Aeronautical Laboratory compared various manned satellite schemes and concluded that the first manned satellites should be ballistic entry vehicles launched with existing intercontinental ballistic missile propulsion systems. Studies of this type of vehicle were intensified at Langley, and by June 1958 the details of such a vehicle were outlined. At this time a working group of personnel from NACA Langley Aeronautical Laboratory and from the NACA Lewis Flight Propulsion Laboratory was formed to delineate a complete manned satellite program.

By May 1958, the Air Force development plan, prepared with the assistance of NACA, was submitted to the Advanced Research Projects Agency.

ARPA, in the meantime, had received several proposals from the services and industry.

Service proposals

The Army proposal to ARPA, known as Project Adam, was to place a man in a recoverable capsule which would be boosted through a ballistic trajectory to a height of about 150 miles, with a recovery by parachute about 150 miles downrange from the starting point. This had a number of merits. By making use of the well-developed Redstone booster, the time period and the cost would be at a minimum and the reliability would be at a maximum. It was anticipated that the United States might thereby achieve a space "first," which would give the United States a much-needed propaganda advantage. In addition, it would provide a 10-minute test of man's reaction to weightlessness during his coasting period outside the sensible atmosphere of the earth.

The Navy proposal, known as Project MER, was to send a man into orbit in a collapsible pneumatic glider. The glider would be launched with its occupant in the nose of a giant booster, placed in orbit, inflated, and then flown down to a water landing by its pilot. The very high temperatures normally associated with reentry would be avoided by using an extremely light structure which would permit slowing down in the very thin atmosphere at extreme altitudes. Even so, a special materials development would have been necessary both for the fabric and the wing leading edge material.

The Air Force proposal was to place a man in orbit with an ICBM booster, plus a suitable upper stage, observe the man's capacity to withstand the environment and function effectively, and then recover him by a ballistic reentry in which the man would be only a passenger. The reentry would be initiated with a retrorocket. A beacon and other devices would be used to help locate him, and a parachute would be used to effect a safe landing.

In reviewing these proposals, ARPA felt that while the Army's proposal had merits, it was not a direct step toward placing a man in orbit, and the siphoning of funds available for that objective would delay the solution to this problem. The Navy's proposal had the difficulty that the weight in orbit exceeded the capability of any booster that would be available for several years. In addition, it was felt that the ballistic-type reentry was fairly well understood from experiments with IRBM's and ICBM's and that a safe flown reentry might require a considerable period of time after booster availability. Both proposals were, therefore, rejected.

The plan that was finally adopted was essentially along the lines proposed by the Air Force. The objectives of the program were to develop a biocapsule capable of providing a man with a suitable living area in the hostile surroundings of space for a period of about 24 hours, to observe a man's capacity to survive and to be useful in such an environment, and to develop a capability for recovering him from orbit by a ballistic reentry.

The program adopted by ARPA, involved starting from small recoverable satellites and working up to large recoverable satellites. The small recoverable satellites for engineering experiments were already being planned as part of the Discoverer program. Mice and small primates were then included in the recoverable package. Animal flights, of course, would be preceded by the development of a suitable life-sustaining package and by measurement of temperatures, accelerations, and other items that would be encountered during reentry into the earth's atmosphere.

The small recoverable satellites were to be followed by a series of middle-sized packages using a Thor booster with a suitable upper stage, partly because large boosters would not be available early enough and partly because it appeared desirable to take a smaller step forward than was involved in going to the full-sized, man-carrying satellite. Finally, the full-sized biocapsules would be orbited, using an ICBM booster, and recovered, first carrying only instruments to measure the suitability of the environment for sustaining life, then larger primates, and finally a man when the desired reliability had been achieved.

The planning for this program was done by ARPA in cooperation with the Air Force, the Office of the Secretary of Defense, and the NACA. The NASA had not as yet been created by law, but it was anticipated that there would be a NASA and that the responsibility for this first phase of man in space would probably be shared with NASA or transferred to NASA entirely after the law was passed. NACA was requested to designate a member to the Man in Space Panel and participate in all deliberations. By this means it was hoped, should a shift in responsibility occur, this would result in a minimum change of direction.

In the program that finally emerged, the objectives remained the same—namely, to develop a suitable biocapsule to place a man in orbit, to observe his capacity to live and function there, and to recover the man and capsule safely.

By June 1958 the Air Force had obtained approval from ARPA to proceed with study contracts on the ecological aspects of the manned space capsule, through the construction of a mockup. Two 3-month contracts, totaling $740,000, were awarded to North American Aviation, Inc., and General Electric Co. for the life support system development. The two contractors then started a phase I development competition for the study and design of a space cabin and internal ecological subsystems. The competition was conducted through the contract period, and although a winner was selected, the Air Force program was not continued as the mission was transferred to the NASA along with the results of the competition. Another selection process was later initiated by the NASA.

Study program

During 1958 personnel of the NACA Langley Aeronautical Laboratory (now NASA Langley Research Center) undertook many research and development tests of both model and full-scale configurations. These tests included:

(1) Aerodynamic data for the capsule.
(2) Aerodynamic data for the solid-fuel booster.
(3) Model and full-scale water-impact tests of the capsule.
(4) Model and full-scale airdrops of the capsule and parachute system.
(5) Design, construction, and centrifuge proof tests of a formed-couch pilot support system.

During this same period personnel of the NACA Lewis Flight Propulsion Laboratory (now NASA Lewis Research Center) conducted studies, jointly with Langley personnel, on the structural design, control systems, and overall system integration of the capsule.

Program approval

In August 1958, the President directed the assignment of the program and the transfer of $30 million of the fiscal year 1959 funds from ARPA to NASA. On September 17, 1958, the joint NASA–ARPA Manned Satellite Panel was established. This panel, with the aid of detailed studies by staff members of the NASA Langley and Lewis Centers, and with the advice and assistance of the military services, formulated specific plans for a program of research leading to manned space flight. The specific plans derived by the Manned Satellite Panel were presented to the Director of the Advanced Research Projects

Agency and to the Administrator of the National Aeronautics and Space Administration on October 3 and 7, 1958, respectively. Upon the approval by the Administrator of NASA, on October 7, 1958, the Space Task Group was organized from personnel of the NASA Langley and Lewis Research Centers and immediately began operations at Langley Field, Va.

Concepts of the plan

Objectives.—The objectives of Project Mercury are to achieve manned orbital flight and successful recovery at the earliest practicable date, and to study man's capabilities in a space environment.

Basic principles.—In order to insure early accomplishment of these objectives, it was decided to use the simplest and most reliable approach available; to use a minimum of new developments; and to have as an integral part of the test program a progressive buildup in speed of ballistic flights of full-scale capsules.

Methods.—The methods conceived for adhering to the above-noted basic principles were to use a drag or basic reentry vehicle placed in orbit by an existing ICBM booster. The descent from orbit was to be initiated by firing a retrograde rocket, and the final landing was to be accomplished by a series of parachutes. Further, the capsule was to be equipped with an escape system which would remove the capsule from the vicinity of the booster, in the event of booster malfunction, and allow the safe return of the man through the use of the standard reentry and recovery system.

Flight program.—The types of flights involved in the buildup program would include:

1. Air drops: Drops of full-scale capsules from cargo aircraft to develop the parachute and recovery system.
2. Escape rockets: Ground launches of the capsule and escape rocket to develop this system under simulated aborted-launch conditions.
3. Balloon flights: High altitude (approximately 85,000 feet) flights to qualify the capsule and its components during a 24-hour soak in near-space conditions. Similar flights will be used as pilot training missions later. (Balloon flights were subsequently canceled.)
4. Ballistic flights: Ballistic flights to approximately 6,000 feet per second using solid-fuel boosters to develop capsule systems and components; ballistic flights to approximately 6,000 feet per second using a modified Redstone booster to qualify capsules and components and later for pilot training missions; ballistic flights to approximately 16,000 feet per second using Jupiter boosters to qualify capsules and components; and ballistic flights to 25,000 feet per second using Atlas boosters first for heatshield development and later to qualify capsules and components. (Jupiter booster flights were subsequently canceled.)
5. Orbital flights: Orbital flights of two to three orbits to qualify the complete system; later manned flights of two to three orbits when warranted by system reliability; and finally manned orbital flights of up to 24 hours' duration.

Manned space capsule

On October 28, 1958, preliminary specifications for a manned space capsule were distributed to industry and on November 7, 1958, a contractors' briefing was held by the Space Task Group at Langley Field, Va., for some 38 potential bidders on the capsule. Subsequent to this briefing, more detailed specifications were prepared and on November 14, 1958, were distributed to about 20 manufacturers who had stated an intention to bid. The procedures used by NASA to select a contractor for the capsule were presented to the Committee on Science and Astronautics at the 1960 NASA authorization hearing on April 24, 1959. An extract of the testimony is as follows:

NASA Procedure Used in the Selection of a Contractor for the Project Mercury Capsule

1. Chronologically, the following steps were taken in order to select a capsule contractor for Project Mercury:

(*a*) On October 23, 1958, preliminary specifications prepared by NASA were mailed to prospective bidders. These specifications outlined the technical concepts and, in addition, presented suggested methods of analysis and construction.

(*b*) A bidders' conference was held at Langley Field, Va., on November 7, 1958. Thirty-eight firms were represented at this conference. The specifications were reviewed and further technical details were presented.

(*c*) On November 17, 1958, final copies of NASA specifications S–6 were mailed to 20 firms who had indicated by telegram that they desired to be considered as bidders.

(*d*) Twelve companies submitted final proposals by December 11, 1958, the deadline for submission of such proposals. These companies were:

1. Avco Research & Development Division.
2. Chance Vought.
3. Convair, Astronautics.
4. Douglas Aircraft, Inc.
5. Grumman Aircraft Corp.
6. Lockheed Aircraft Corp.
7. Martin Co., Denver (with RCA, Astro-Electronic Products Division).
8. McDonnell Aircraft Corp.
9. North American Aviation, Inc., Los Angeles (with General Electric MSVD).
10. Northrop Aircraft Corp.
11. Republic Aviation Corp.
12. Winzen Research Laboratories.

2. The evaluation of the proposals submitted by the competing companies for this contract was carried out with great thoroughness and involved a great many man-hours on the part of our top engineers. The capsule contractor was selected only after a detailed technical assessment, and management, cost, and production assessment of all of the proposals. Eleven teams, with a total membership of 31 men, evaluated specific technical areas. These teams reported to a six-man technical assessment commit-

tee. Concurrently, the management, cost and production proposals were evaluated by a seven-man committee, and proposals were rated on six separate factors. The technical assessment committee was not informed of the contents of the management and cost proposals. The two assessment committees made separate presentations to a source selection board.

3. After careful evaluation of the technical and administrative factors, the source selection board submitted its findings to the Administrator, NASA, with a statement that McDonnell Aircraft Corp. had scored the highest combined rating. On the basis of all the findings presented to him, the Administrator awarded the contract to the McDonnell Aircraft Corp.

Final negotiations leading to a contract award were then entered into. These negotiations were completed on January 26, and the detailed contract was signed on February 6, 1959.

Boosters

Upon approval by the Administrator of NASA of the program presented by the Manned-Satellite Panel, the Space Task Group began final negotiations for the booster vehicles required in the program.

Two general types of boosters were required: first, large liquid-fuel ballistic-missile boosters for orbital flights and for hardware qualification flights, and smaller solid-fuel boosters for research and development flights.

Visits were made by Space Task Group personnel to the Air Force Ballistic Missile Division (BMD), Los Angeles, Calif.; to the Army Ballistic Missile Agency (ABMA), Huntsville, Ala.; and to the Air Force Missile Test Center, Patrick Air Force Base, Fla. Visits were made by BMD and ABMA personnel to the Space Task Group at Langley Field, Va. On these visits arrangements were made for the required ballistic missile boosters for the program.

The Langley Research Center was asked to provide the solid-fuel boosters. The preliminary design of these boosters was made by the Langley staff and contracts were let by Langley for the solid-fuel motors and for the detail design and construction of the airframes.

PART II

MERCURY SYSTEMS

General

The Project Mercury capsule or satellite system is illustrated in figure 1. This system consists of the ballistic capsule, fitted with the

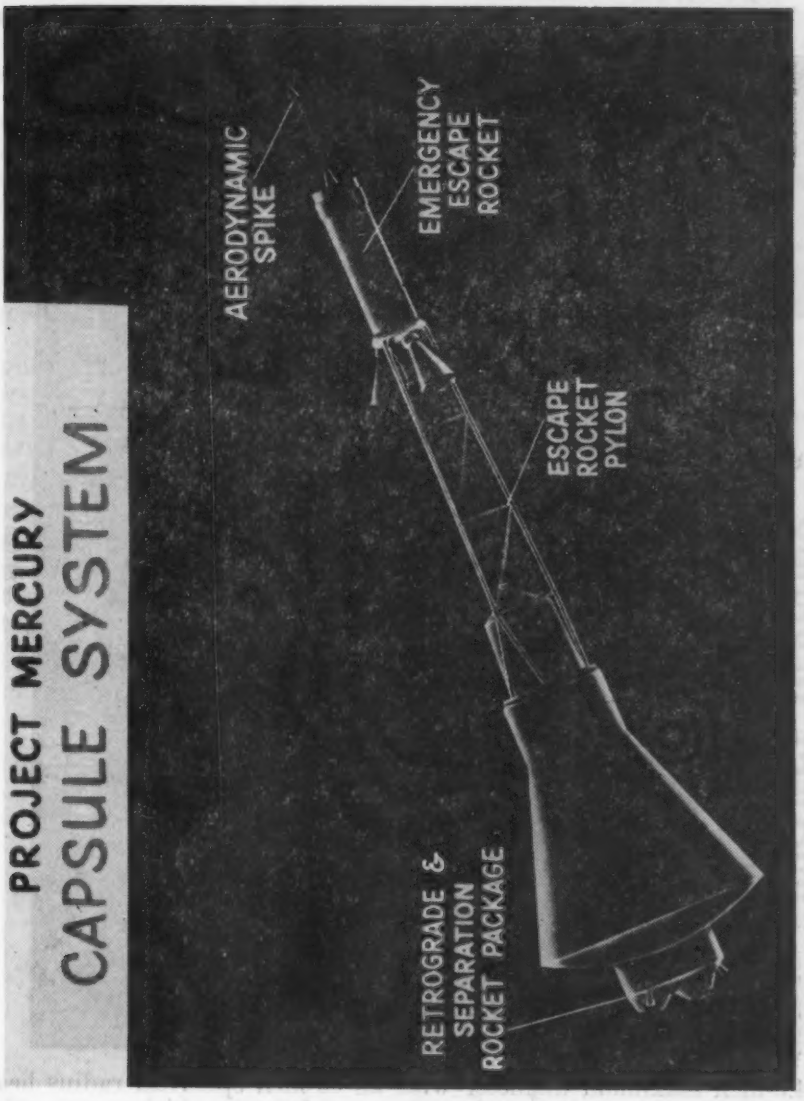

FIGURE 1

retrograde and separation rocket package, escape rocket pylon and an emergency escape rocket. The retrograde and separation rocket package contains small, solid propellant rockets used first to separate the capsule from its booster and later on to initiate the descent of the capsule from its satellite orbit. The emergency escape rocket, mounted on top of the escape rocket pylon, serves the function of separating the capsule from the booster and carrying it away from the booster should a booster malfunction occur. The aerodynamic spike, pictured on top of the emergency escape rocket, is used to minimize the aerodynamic drag forces during the ascent trajectory.

Ballistic capsule

The ballistic capsule is illustrated in figure 2; the capsule has a

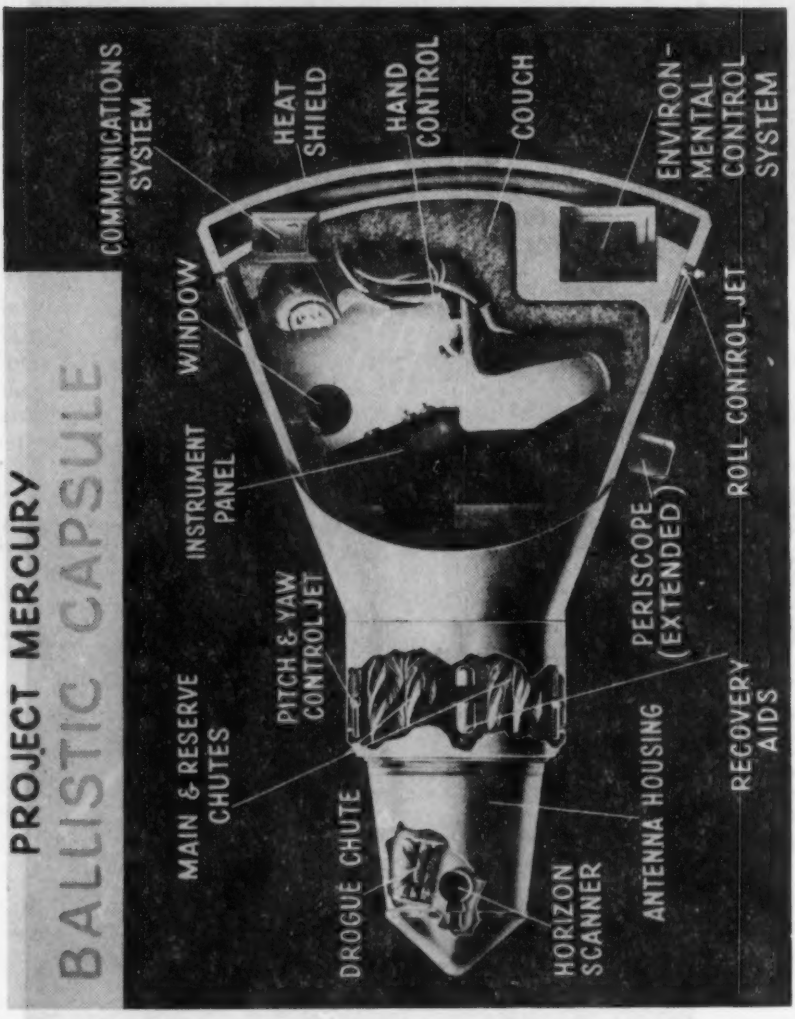

FIGURE 2

74.5-inch maximum diameter with an 80-inch spherical radius heat shield. The afterbody consists of a cone frustum which contains the pilot's pressure vessel, a 32-inch diameter cylinder which contains the

parachutes and onboard recovery system, and a cone frustum which forms the communications antenna and contains the drogue parachute and horizon scanner. Attached to the top of the antenna canister is a destabilizing mechanism. This mechanism insures that the capsule will reenter with the heat shield forward, even if the control systems should fail.

The capsule has high aerodynamic drag in order to minimize reentry heating. It will reenter the atmosphere with the large blunt end forward. The heat of reentry will be dissipated by an ablation heat shield. As mentioned earlier, the descent from orbit of the capsule will be initiated by a cluster of solid propellant retrorockets which are affixed to the heat shield. Parachutes are provided for the final stages of descent.

In orbit, the capsule's attitude is sensed by an infrared horizon scanner, while the attitude control is achieved by small reaction jets.

Within the pressure-tight capsule, the pilot is supported in a form-fitting couch. Centrifuge tests at the Navy's Johnsville facility have demonstrated that in such a couch man can stand considerably more than the maximum accelerations and decelerations that he will encounter in flight.

An environmental control system will maintain the cabin's atmosphere within prescribed limits; and a communications system will telemeter important functions to ground stations in addition to permitting voice communication between the pilot and the ground.

Although the entire operation can be completely automatic, the pilot will have important back-up functions. The navigation periscope, together with the manual control system, will enable him to navigate and to fire the retrorockets at the proper time should the need arise.

Flight trajectory

A typical flight trajectory is illustrated in figure 3. The manned satellite will be launched from Cape Canaveral with an essentially unmodified Atlas booster. The first illustration in the sequence in figure 3 shows the Atlas with the capsule and the escape system mounted on top of it. The use of the escape system will be described later.

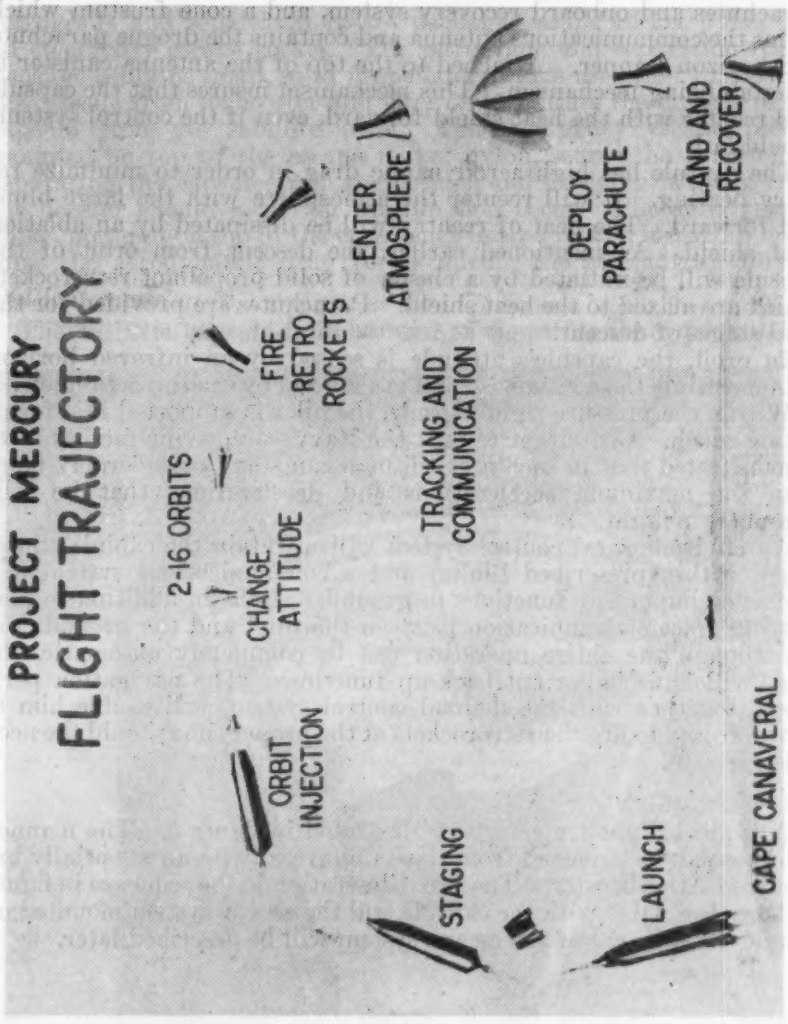

FIGURE 3

In a normal launch, the escape system will be jettisoned shortly after Atlas staging; the Atlas has then left the atmosphere so that the danger of a high order explosion has been eliminated. An escape after staging would be executed by shutting down the Atlas motor and separating the capsule with small separation rockets, normally used at orbit injection. Jettisoning the escape system at staging also avoids lifting unnecessary weight into orbit.

Normally, the Atlas sustainer carries the satellite into orbit where separation is accomplished with small separation rockets mounted on the capsule. The attitude control system will then aline the capsule in a heat shield-forward position. While in orbit, the capsule will be tracked, and periodic communication with ground stations will be

possible. By use of the manual control system, the pilot can override the automatic system, thus enabling him to observe either the ground or the sky.

After a predetermined number of orbits, the retrorockets will slow the capsule by about 500 feet per second to put it into a shallow descent trajectory toward the atmosphere. The retrorockets are then jettisoned.

Atmospheric entry must be made at a very shallow angle in order to minimize the decelerations. In a normal reentry, the peak deceleration is about 9 g.'s or about the same as a peak acceleration during boost. After the capsule has been slowed to near sonic speed by atmospheric drag, a drogue chute is deployed to minimize subsonic oscillations. Final descent is accomplished by a large parachute designed to give a landing speed of 30 feet per second. A water landing is programed.

Escape system

One of the most important components of the Mercury system is the escape system illustrated in figure 1. It is well recognized that, without a highly reliable escape system, it would not be possible to attempt a manned space flight mission in the period of the next few years. Consequently, a great effort is being spent on the design and qualification of an escape system which can carry the manned capsule away from the Atlas, should the booster malfunction. The escape system consists of a tower, above the capsule, supporting a solid fuel rocket which exhausts through canted nozzles to the rear. The escape sequence is as follows:

(1) The capsule is disengaged from the booster and simultaneously the escape rocket is fired.

(2) The escape rocket pulls the capsule forward and to the side of the booster with the separation of at least 200 feet in a second.

(3) The capsule and tower coast until they slow down; the tower is then jettisoned and a normal parachute-sequence landing is begun.

Orbital flight

Although the satellite system is designed for flight times slightly in excess of 1 day, initially only three orbits will be attempted. As illustrated in figure 4, the satellite will be launched north of east from Cape Canaveral, with orbit insertion between Cape Canaveral and Bermuda. If for some reason orbit injection cannot be made, immediate action to abort will be taken; in this manner all aborted landings can be confined to the Atlantic Ocean.

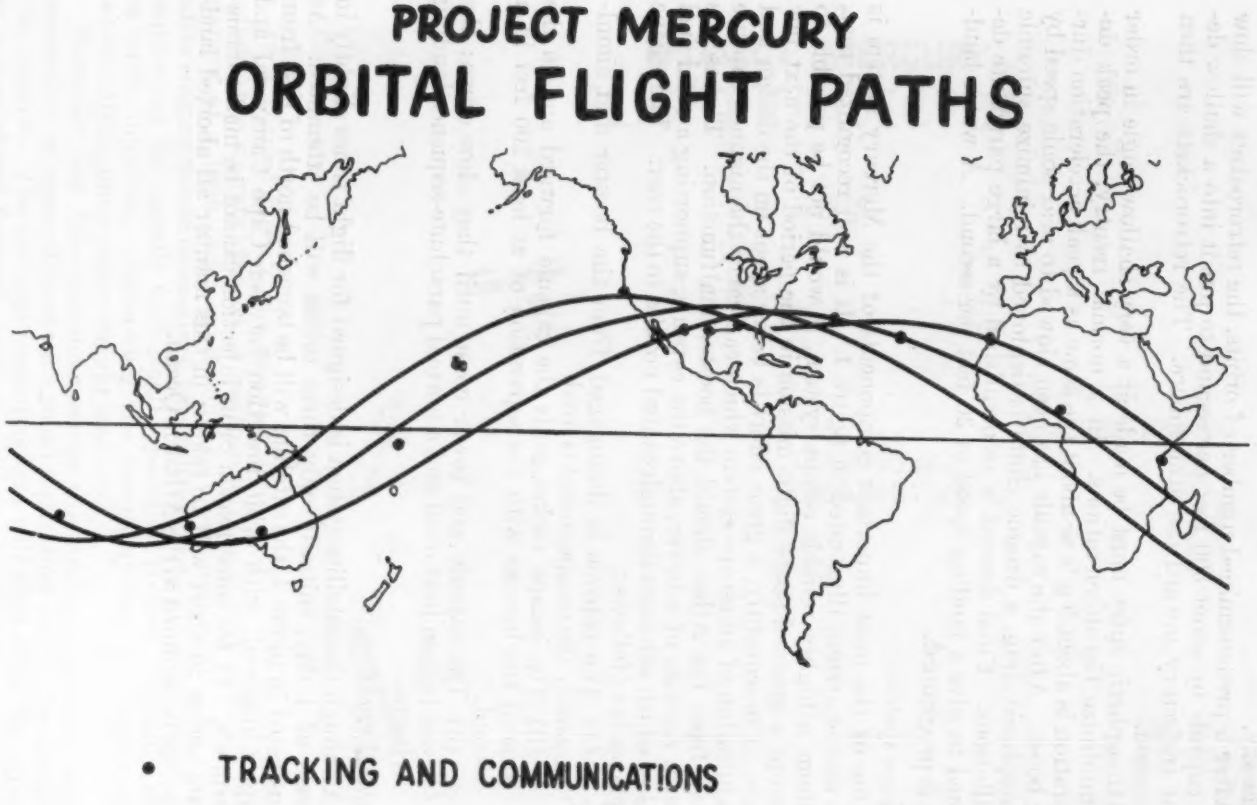
PROJECT MERCURY
ORBITAL FLIGHT PATHS
• TRACKING AND COMMUNICATIONS

FIGURE 4

Precision orbit determinations will be made during the first two turns around the earth. On the third orbit, the retrorockets will be fired near the California coast. Continuous tracking will then help provide accurate impact predictions. The landing and recovery will be made along the Atlantic Missile Range.

Retrograde rocket system

The return of the capsule from orbit is initiated by the firing of a retrorocket system, shown in figure 1, which slows the capsule from orbital velocity to approximately 500 feet per second below orbital velocity. Three separate rockets are used for this maneuver. Each of the three has its own prime and reserve ignition system, so that utmost reliability can be assured. In an emergency, any one of the three retrorockets could bring about reentry, although for expeditious recovery, all three are needed. Because no "off-the-shelf" rockets were available to meet the weight and velocity requirements, a new rocket is being developed specifically for the Mercury program. An extensive development and qualification program for this engine is required. Many space simulated firings will be made in ground test facilities prior to actual flight.

Landing and recovery system (onboard)

Extensive equipment is carried on board the capsule in order to effect a safe landing and to aid in expeditious recovery of the floating capsule. Equipment is shown in figure 2.

The landing and recovery system consists of the following major items:

A 6-foot drogue parachute mounted in the top of the antenna fairing. This parachute is fired by the drogue mortar and is used for deceleration and stabilization of the capsule between the altitudes of 45,000 and 10,000 feet.

A 63-foot ring-sail main parachute.

A 63-foot ring-sail secondary parachute with its attendant pilot parachute. The pilot parachute is deployed by a mortar-fired slug which is attached by cable to the pilot parachute.

Two ejector bags are located in the bottom of the main and reserve parachute compartments. These bags are gas filled by electrically actuated cartridges. Their primary purpose is to eject, after landing, either parachute which may remain unused; but they are also actuated during the landing sequence to assist in normal parachute deployment.

Two barostats (switches which close at a particular altitude) are installed in a parallel system which translates measured pressure into an electrical signal used to sequence certain events in the recovery procedure.

A sequence control package for automatic control of the recovery system is included. This package has two parallel systems, either of which will operate the recovery systems through its full sequence. The two parallel systems are equipped with electrical devices so that failure of a component in either system will cause the equivalent component in the parallel system to perform its function. This system assures a high degree of reliability.

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An impact switch: This inertia switch is set at 6½ g's. It is armed by the sequence control package after parachute deployment. In turn, it arms and/or operates some of the recovery aids after landing.

Two pilot-operated pull rings and three pilot-operated switches: These switches and rings provide manual override or backups to the automatic system.

Radar reflective chaff: One packet is packed with and released with each parachute.

Dye marker: This is packed with the reserve parachute and attached to the capsule by a small cable.

SOFAR bombs: Two such depth charges, used as recovery aids, are placed on top of and ejected over the side of the capsule by the parachute ejector bag.

Four flotation bags: These are 3-foot-diameter, 2-foot-long, cylindrical, air-filled bags, which are clustered about the cylindrical section of the capsule. The capsule is relatively stable with the pilot in his seat but becomes unstable during top egress from the capsule. These flotation bags prevent the egress end of the capsule from going below the surface of the water.

The recovery system is operated in the following manner: Separation of the escape pylon arms the recovery system through a time delay. After the capsule reaches 45,000 feet on its descent, the dual barostat actuates the drogue mortar which ejects the drogue parachute. In the case of drogue mortar failure to fire from the barostat signal, the pilot may use the drogue switch on the left-hand console to fire the drogue mortar. Failure of the drogue parachute to deploy is not a catastrophic failure. The capsule will not be as stable and will oscillate more (these oscillations can be stopped by the attitude-control system) and the descent will be at a higher speed; however, the main and reserve parachutes are designed to effect positive deployment even under this higher speed condition. At 10,000 feet altitude, the low-altitude portion of the barostat signals the antenna fairing ejector gun which ejects the antenna fairing and drogue parachute; the drogue parachute, in turn, pulls the main parachute and chaff from its compartment. The main parachute ejector bag is also fired at this time. In case of failure of the electrical squib of the antenna fairing ejector gun, red light at "Main deploy" indicates the pilot should operate the pull ring which sends both a new electrical signal to the gun and actuates a gas initiator which supplies pressure to the gas-operated squib of this gun. The 10,000-foot signal from the barostat also dumps any remaining hydrogen peroxide fuel after a time delay. The periscope is extended automatically from this signal so that the pilot may watch for the blossoming of the parachute above him.

In case the main parachute fails to deploy, or if the parachute deploys but does not open, the pilot will sense this by the lack of shock loading and/or the failure of the parachute to show in the periscope and window. No light will show at "Reserve deploy." The pilot action is to pull the reserve deploy switch. This ring electrically actuates the main parachute disconnect, the reserve parachute deployment gun, and the reserve parachute ejector bag. The pull ring also actuates a gas initiator which provides pressure to the gas-operated squib of the deployment gun thereby providing additional backup.

The deployment gun fires a 1-ounce slug which is attached to the pilot parachute by a cable. The pilot parachute pulls the reserve parachute, chaff, dye marker, and SOFAR bombs from the parachute compartment assisted by the reserve parachute ejector bag.

The signals which deploy the main parachute at 10,000 feet or deploy the reserve parachute, also arm the dual inertia switch through a time delay. This delay is for the purpose of preventing a possible operation of the impact switch through the shock of a parachute opening. The dual inertia switch is actually two inertia switches with crossover which enables either switch to serve either side of a parallel system. The time delay unit is designed to restart its signal if a second signal reaches it. Upon normal landing by use of the main parachute, the inertia switch will actuate the main parachute jettison squib. In order to save power, the inertia switch turns off those electrically powered systems that are no longer needed. It turns on the rescue beacon, high-frequency backup transceiver, the ultra-high frequency backup transceiver, and recovery flashing light. The inertia switch has armed the pilot-operated switch labeled "Rescue switch." Actuation of this switch will disconnect the reserve parachute and will actuate the pilot parachute deployment gun and the reserve parachute ejector bag, if these have not already been fired to deploy the reserve parachute during landing. This switch also provides a signal to energize the relays that start the operation of the electrical rescue aids. Actuation of the rescue-aid switch by the pilot will cause the balloon antenna to fill with helium after a time delay sufficient to clear the reserve parachute from its compartment. The four flotation bag compartment covers will be ejected from the capsule by squib cartridges from this same signal and the flotation bags will be filled with air.

Environmental control system

The environmental control system, shown in figure 2, must provide livable conditions for the astronaut throughout the period of capsule occupancy. The system is designed to provide a sufficient supply of oxygen to sustain life for 40 hours and to maintain cabin pressurization in normal flight or suit pressurization under emergency conditions. A safe level of carbon dioxide is maintained and the temperature of both the astronaut and cabin are kept within a safe level. The excess water produced by the astronaut is removed.

The system consists of two high-pressure oxygen sources which provide oxygen to a closed pressure-suit circuit and to the cabin-pressurization regulator valve. The oxygen sources are connected so that the second source is automatically activated upon depletion of the primary supply. The closed pressure-suit circuit has two pressure-suit connections that couple to the suit at the torso and helmet. The closed cycle has a lithium hydroxide canister to remove carbon dioxide and odors, a blower to circulate the air, a water-boiler type of heat exchanger to remove the astronaut's heat output, and a pulsating vinyl sponge water-removal system to remove the astronaut's excess water given off in the body-cooling process.

The cabin system consists of a cabin-pressure regulator valve which meters oxygen to maintain a 5-pound-per-square-inch cabin pressure, a water-boiler type of heat exchanger to remove the electrical heat out-

put of the various electrical equipments, and a blower to circulate the cabin air.

Basically, the system operates as follows:

Closed-suit circuit.—Oxygen is metered into the closed pressure suit to maintain a 100-percent oxygen atmosphere. The gas mixture is circulated at a continuous-flow rate through the pressure suit where the gas picks up carbon dioxide, water, and heat. The gas then is passed through the lithium hydroxide canister to remove CO_2 and keep the CO_2 partial pressure within proper limits. The gas is then cooled by using a water-boiler heat exchanger. (The astronaut's heat output is used to evaporate a nonmixing water stream and the water vapors are vented overboard.) The body water that condenses in the heat exchanger is entrained in the stream and is caught in a vinyl sponge. This sponge is automatically squeezed periodically to force the entrapped water into a storage container.

Cabin system.—Oxygen is metered into the cabin to maintain the proper cabin pressure. A blower provides circulation and a heat exchanger maintains the cabin temperature. A separate oxygen supply is activated during the launch phase to purge and enrich the cabin air with oxygen. The cabin has a safety valve system to prevent overpressurization. In addition, a snorkel inlet and exit are installed to provide ambient air for suit and cabin ventilation after reentry. The cabin air pressure is approximately the ambient pressure during launch up to 27,000 feet where the cabin is sealed. During descent, the snorkel valve opens at 20,000 feet and the pressure is again approximately ambient until touchdown.

The environmental control system may be used in four modes of operation as follows:

1. *Normal operation.*—The astronaut, during normal operation, may fly on the closed circuit with the visor down. In this condition, the suit will not be pressurized and ventilation air will be circulated through the suit. The pilot also has the option of flying with the visor up and breathing part cabin air and part closed circuit air. In this mode of operation, 56 hours of oxygen are available.

2. *Emergency operation (loss of cabin pressure).*—In the emergency mode of operation, the suit will be pressurized to 5 pounds per square inch and the astronaut will be supplied with oxygen on the closed circuit. System duration remains unchanged.

3. *Dual emergency operation (loss in cabin pressurization and a failure in the closed circuit).*—In dual emergency operation, the oxygen flow will automatically be passed directly through the pressure suit and will be exhausted into the cabin. The system duration is greatly reduced in this mode of operation and is limited to 3 to 6 hours of operation.

4. *Emergency operation (failure of closed-suit circuit).*—The astronaut would have the option of breathing the cabin air or of operation as in item 3 above on an emergency oxygen flow through the suit.

An environmental control system trainer will be used for training and system evaluation. This unit will contain a complete environmental control system, instrumentation, and a heating blanket to simulate reentry heat loads. The unit will be placed in a high-

altitude chamber for extensive tests and simulated training flights in which various emergency and normal flights will be simulated. The contractor will conduct 4-hour and 28-hour tests on this unit prior to delivery.

After extensive evaluations of several types of pressure suits, the B. F. Goodrich Co. (Navy) full-pressure suit was selected for use in Project Mercury.

Attitude control system

The attitude control system, illustrated in figure 2, must provide for automatic or manual attitude (roll, pitch, and yaw positions) sensing and control of the capsule throughout flight. Attitude sensing is obtained from a combination of horizon-scanning and gyroscopic equipment. The rotation of the capsule in the pitch, roll, and yaw planes is controlled by a jet reaction system which uses hydrogen peroxide as a monopropellant. While in orbit, the control forces required are very small and a low thrust mode of operation of the reaction jets is required. During retrorocket firing and during atmospheric reentry, a high level of thrust is required. In order to produce the dual level of thrust, two sets of reaction thrust chambers are provided.

In order to increase overall mission reliability, a provision is made for manual attitude sensing and control in case of failure of the automatic system. Extensive simulator runs with proposed control system configurations are being made in order to insure the feasibility of manual operation. Manual control during retrograde rocket firing is a particularly difficult task and much effort is being expended to provide this capability.

FIGURE 5. *Demonstration of pilot mobility with pressure suit inflated*

Crew space layout, controls and displays

In order to arrive at a satisfactory layout of controls, extensive trials of the astronaut's capability with inflated pressure suit have been conducted in a full-scale capsule mockup, figure 5. Because of limited mobility under the inflated-suit condition, satisfactory location of all controls is rather an intricate problem. The astronauts and NASA human factor specialists are working closely with McDonnell in order to arrive at a satisfactory arrangement.

Another area that has received much attention through the use of a full-scale capsule mockup, is that of pilot egress after landing. Should

the pilot find it necessary to leave the capsule after landing, and before recovery, he will have the option of leaving through the top hatch, or through an explosively actuated emergency side hatch.

Communications (onboard)

Since the basic Mercury concept relies heavily on the communications system, particular emphasis and care have been used in the selection of equipment, from the standpoints of reliability, minimum size, weight, and power consumption consistent with the efficiency required for successful operation. Stringent requirements have been placed on the packaging of the units so that they will not be adversely affected by the environmental conditions and shock forces. Although it is desirable to utilize the most recent technological advances and designs, an optimum choice has been made to be certain that all equipment and circuitry have been thoroughly tested and proven. Generally, the time scale and high degree of reliability have dictated use of the best current "off the shelf" items. The redundant capabilities of the communications system are exemplified by the supplementary modes of the following categories:

Two-way voice links which will be able to operate in different portions of the radio spectrum (HF and UHF) to permit use of whichever is optimum at any given time. The UHF recovery phase voice transmitter will be available (from a separate battery supply) for backup if needed in orbit.

Dual transistorized microphone amplifiers feed all transmitters, and as a safety factor each suit earphone has a separate individual transistorized amplifier per earphone.

Dual receivers will be used for the receiving of commands from the ground. This will include such commands as escape rocket firing commands, updating adjustments of the retrorocket firing timer to compensate for flight-path deviations from nominal, as well as possible emergency override commands from the ground to fire the retrorocket, turn on the intermittent telemetry transmitter, etc. An additional facility will be available on the lower frequency channels to provide an extra voice channel if the need should rise. Verification of commands received will automatically go back to the ground over the telemetry link.

Two separate telemetry transmitters will be used to convey information back to ground stations. Semicontinuous operation of one unit will provide signal information throughout the orbit. The other transmitter will give redundant signals in the case of unfavorable conditions, but will operate only when optimum ground contact is insured by airborne receipt of turn-on commands from an inrange ground station.

Tracking capabilities for different types of radar installations will be provided by separate transponder-beacons. Since these radars represent the best tracking accuracy currently operational, they will be the primary tracking means for orbit determination and position fixing, especially for a few passes or portions thereof.

Redundant systems will also be used in the recovery phase. A separate battery supply will power both HF and UHF recovery voice transmitters/receivers. These will be on separate antennas to further enhance reliability. An international distress fre-

quency beacon will operate during parachute descent, and continue until the capsule is recovered. Upon capsule touchdown, a carrier wave beacon for direction finding homing on international distress frequency and the UHF voice transmitter will come into operation. The beacon and HF recovery voice units will feed an antenna wire lifted aloft by an aerodynamically lifting balloon filled with helium upon capsule touchdown. This antenna will be in addition to the operating descent antenna (see below) and will provide more height and better radiating characteristics for HF, yet be relatively independent of capsule attitude. A low-powered, hand-held UHF transceiver is also available in the life-raft kit, for direction finding and voice.

In view of the wide range of requirements for antennas, considerable effort has been expended to achieve designs that will provide the optimum coverage patterns and maintain reliable and efficient com munications, yet be compatible with the vehicle structure and not be affected by aerodynamic heating. To fulfill all of these requirements, all equipment except the radar beacons will share one antenna during the major portion of the mission. To insure maximum utilization of the radar beacons, independent flush-mounted helical antennas are used exclusively for the beacons.

Effective use has been made of the vehicle to comprise part of the main antenna, and yet conform to structural requirements. A bicone-type antenna, contained within a band of dielectric between the parachute compartment and drogue parachute container, serves to isolate the two portions of the vehicle for HF operation, and also serves as a biconical-horn type antenna for the various UHF frequencies. This results in an exceptionally wide-band antenna with radiation in all directions so that communications will not necessarily be dependent on the capsule stabilization system. Special treatment has been given to this antenna to strengthen forward and after lobes of the radiation pattern (the directions where greatest range will be required), and improve radiation around the ends of the vehicle where shadowing would normally occur. By means of a multiplexer-filter network, all of the communication equipment will simultaneously feed this common antenna with little or no degradation to the individual equipment performance. This antenna functions during launch, orbit, and reentry with a minimum of structural and heating problems.

When the capsule has descended to around 10,000 feet, the main parachute is deployed. All material on top of the parachute compartment, including the biconical horn, is jettisoned to avoid complications. Radar beacon operation is not affected since these antenna units are positioned below the parachute compartment. With the removal of the conical antenna structure, the fan monopole antenna contained beneath it, swings up by spring loading. At the same time, a coaxial switch transfers the output of the multiplexer to this descent antenna, which then radiates all signals formerly on the biconical horn, except HF voice. In addition, the SARAH beacon pulses commence from this antenna, and continue during parachute descent and postlanding,

since the antenna protrudes above the uppermost portion of the capsule as it floats in the water. The signal from the recovery voice units also goes on automatically onto this antenna for the direction finding mode.

An additional antenna is provided upon landing by the inflation of a balloon having a shape that provides an aerodynamic lift from wind forces to keep the balloon elevated, and not blow over into the water. The helium that formerly pressurized the reaction jets, fills the balloon bag which lifts up a wire of about 30 feet of length. This antenna transmits recovery voice and direction finding beacon signals.

Instrumentation

The Mercury on-board instrumentation shown in figure 6 has two basic functions:

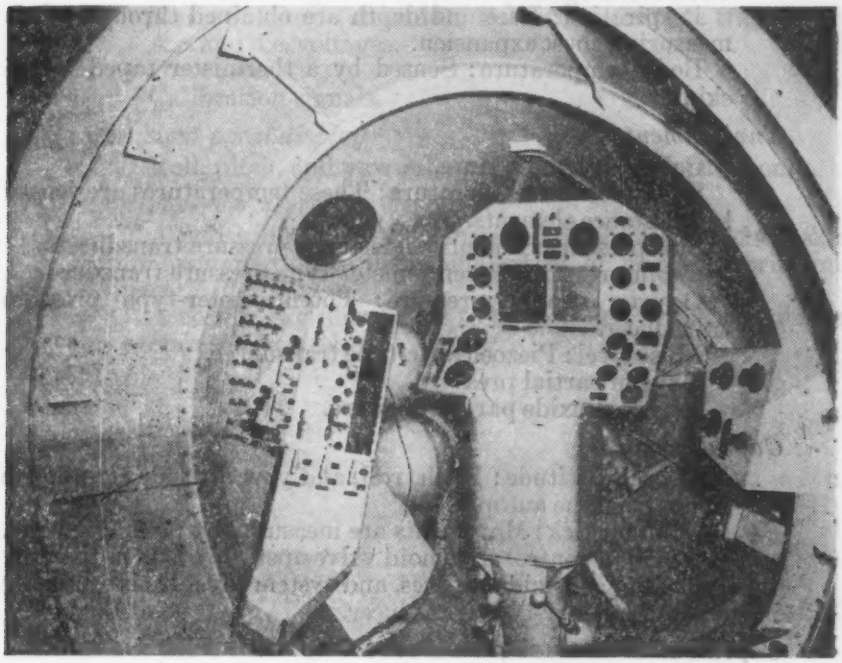

FIGURE 6.—*Interior view of instrument panel and consoles.*

1. To inform the ground personnel of the condition of the capsule occupant and of the operating condition of the capsule equipment.

2. To record permanently, in tape and film form, information about the environment through which the capsule travels and particularly how man and equipment function in this environment.

In order to record or transmit the data to ground stations, the following equipment is carried:

Instrument panel camera: This 16-mm. camera will record instrument panel reading.

Pilot observing camera: This 16-mm. camera will photograph the pilot.

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Tape recorder: This compact recorder has a seven-track capability, 4,800 feet of one-half inch tape, and is the prime data source. All telemetered measurements and pilot voice are recorded on this instrument.

The low-power telemeter transmits aeromedical data and information on capsule operation and environment, continuously.

The high-power telemeter transmits the same information as above, upon ground command.

The following measurements will be made during orbital flight:

Aeromedical

Electrocardiogram: Three electrodes give information, comparable except for frequency response, to a clinical electrocardiogram.

Respiration: Rate and depth are obtained through a belt measuring chest expansion.

Body temperature: Sensed by a thermister taped to the skin.

Environmental

Cabin air temperature.

Suit inlet air temperature: These temperatures are sensed by resistance elements.

Suit pressure: Potentiometer-type pressure transducer.

Cabin pressure: Potentiometer-type pressure transducer.

Oxygen supply pressure: Potentiometer-type pressure transducer.

Noise level: Piezoelectric-type transducer.

Oxygen partial pressure.

Carbon dioxide partial pressure.

Capsule control

Capsule attitude: Pitch, roll, and yaw attitude signals are taken from the autopilot.

Control stick: Movements are measured by potentiometers.

Reaction control: Solenoid valve operation is monitored by recording solenoid voltages, and system pressure is sensed by a potentiometer-type transducer.

Capsule structural temperatures

Inner skin temperatures.

Outer skin temperatures.

Heat sink or ablation shield temperatures: These temperatures are sensed with resistance element-type transducers.

Operations, alarms, and failure signals

Tower separation.

Capsule ring separation.

Retrograde angle command.

Retrograde rockets Nos. 1, 2, and 3 fire.

Retrograde rocket assembly jettison.

Drogue parachute deploy.

Antenna fairing separation.
Main parachute deploy.
Main parachute jettison.
Reserve parachute deploy.
Pilot abort initiate.
Booster failure.
Tower escape rockets.
Electric power failures.

These signals are voltages obtained from the various circuits.

General

Time: Clock output.
Time of retrograde: Clock output.
Static pressure (altitude): Potentiometer type transducer.
A.c. and d.c. voltages.
D.c. current.
Calibration signals.

Instrument panel display

Roll, pitch, and yaw rates: Displayed on the panel only.

Post recovery observation

A polished plate is to be installed on the capsule outer skin for examination to determine extent of micrometeorite impact.

A cosmic ray filmpack is to be installed in the capsule for examination on return.

PART III

MERCURY RESEARCH AND DEVELOPMENT PROGRAM

Although the Mercury concept is the simplest possible approach to manned flight in space, involving a minimum of new developments, a great deal of research and development remains to be done. For flight within the atmosphere, the capsule must be stable over the widest speed range yet encountered by any vehicle—from satellite velocity to a very low impact speed. And in orbital flight all the systems must function properly in the weightless state. The capsule must be compatible with the launch rocket and must be "at home" in the water while awaiting recovery. A developmental program of this magnitude requires the use of many different facilities and techniques. Among those being utilized for Project Mercury are the following:

Wind tunnel programs.
Small-scale free-flight tests.
Aircraft drop tests.
Aircraft-launched drogue parachute tests.
Pad escape tests.
Little Joe full-scale flight tests.
Atlas-boosted reentry test (Big Joe).

Wind tunnel programs

The wind tunnel tests have utilized facilities of the Langley and Ames Research Centers of NASA and the hypersonic facilities of the U.S. Air Force Arnold Engineering and Development Center. In these facilities capsule models have been tested over a mach number range from low subsonic to 20.

A typical wind tunnel installation of a Project Mercury model is shown in figure 7.

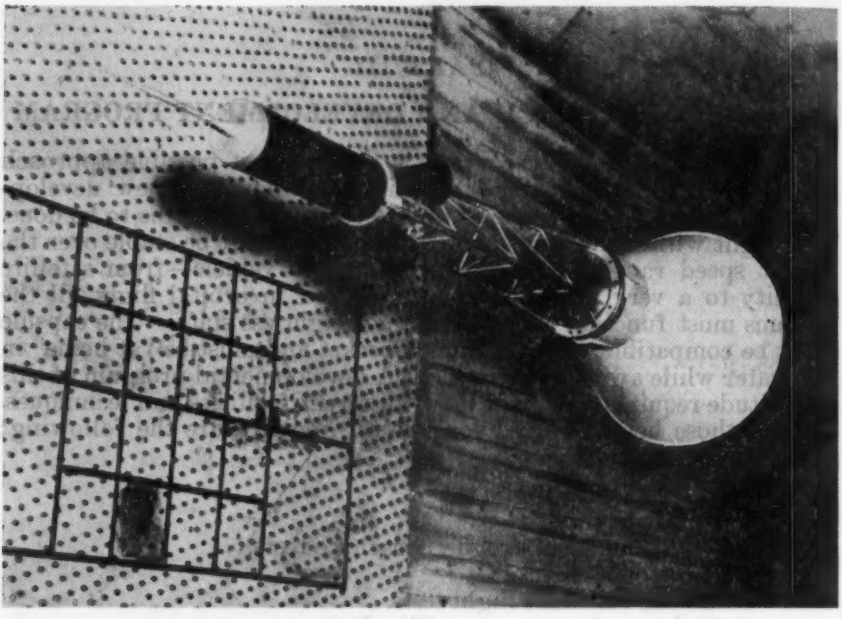


FIGURE 7.—*Thirty-two percent scale model of escape configuration in AEDC (Tullahoma) 16-foot propulsion wind tunnel.*

During these tests, the aerodynamic coefficients, stability derivatives, and heating characteristics were determined for the capsule less booster, with and without the escape tower; and the capsule in combination with the Little Joe, Redstone, and Atlas boosters. In all, it was necessary to evaluate approximately 50 models to cover the complete range of variables and configurations. By August 1959 the wind tunnel program was essentially completed, and results were incorporated into the McDonnell Aircraft Corp. production design and into booster control requirements. In addition, the availability of these data on the various configurations allowed precise calculations of flight trajectories and capsule motion to be made in place of the less precise preliminary estimates.

Although the wind tunnel results and theoretical calculations can provide many of the answers needed in a development program, frequently it is necessary to resort to actual flight tests to provide portions of the data required. Such flight tests are described in the following sections.

Small scale free flight tests

Small scale flight tests using multistage rocket propelled models are being used in the Mercury program to obtain dynamic stability data at transonic, supersonic, and hypersonic mach numbers, and to obtain aerodynamic heating and pressure distribution data under realistic entry conditions without wind tunnel mounting (sting) or sidewall effects.

The first model flight accelerating a capsule model to hypersonic speeds was made in August 1959; a mach number of about 10 was reached. Results from this flight indicated substantial agreement with wind tunnel and theoretical results.

Aircraft drop tests

In order to develop the parachute and recovery aids configurations for the capsules, the aerial drop technique has been used. A number

FIGURE 8.—*Recovery capsule being loaded in TAC C–130 drop aircraft.*

of full-scale boilerplate capsules with various parachute and recovery aid configurations have been dropped from C–130 aircraft. Preparation for a typical drop operation is illustrated in figure 8.

Early in the program, the systems plan called for release of the beryllium heat sink from the capsule after reentry but prior to land-

ing. During drop tests, this procedure was determined to be impractical, and an alternate design that would obviate the need for releasing the heat sink was devised. The main parachute originally proposed for Project Mercury was an extended skirt type; however, during one of the early tests in the program, this parachute failed to open completely. An alternate parachute design, called a ring-sail type, was immediately specified. A large number of drops with this alternate design parachute have been successful. In addition to the parachute design change, the method of deploying SOFAR bombs was found to be deficient and was changed during the development program. The flashing light and dye marker recovery aids have been proven satisfactory and SARAH beacon operation has been evaluated. Although the air drop technique can be used to investigate the terminal phase of the reentry and recovery maneuver, higher velocities than can be obtained by this technique are required for the drogue parachute developmental tests.

Aircraft-launched drogue parachute tests

In order to evaluate the drogue parachute system at the required velocity and altitude, an air-launch technique with an F–104 airplane is being used. These tests are being conducted at the NASA Flight Research Center in California. A total of 14 tests have been conducted to date at transonic mach numbers. As a result of these tests, several changes in canopy and riser construction have been made, and a satisfactory drogue parachute has evolved. Additional tests will be required in order to evaluate the system under all entry conditions.

Pad escape tests

From the beginning of Project Mercury, it was clear that large liquid propellant boosters would not, within the time period considered, be reliable enough for human occupancy, unless an exceedingly reliable escape system could be devised to cope with all emergencies. In order to meet this requirement, the tower escape system, illustrated in figure 1, was devised. A new solid propellant rocket, having multiple canted nozzles, was required. This rocket must pull the capsule rapidly away from the booster at any time an unsafe condition requires separation. Such a requirement may exist with the capsule and booster resting on the pad or in flight. In order to determine the adequacy of the proposed escape system for an off-the-pad escape, several scale-model and full-scale tests were made. In the first full-scale test with a boilerplate capsule and escape rocket assembly, the capsule was observed to gyrate in a completely unacceptable manner during the escape maneuver. Subsequent recovery of the expended escape rocket confirmed that asymmetrical thrust had occurred and was caused by a nozzle failure of the boilerplate escape rocket. A change was made in the boilerplate escape rocket, and a successful off-the-pad test was then accomplished. This test proved the soundness of the tower escape system concept, but did not provide a test of any actual flight-type hardware. On July 22, 1959, a prototype of the actual Mercury escape rocket, figure 9, was utilized in a successful off-the-pad escape test. Further tests are planned.

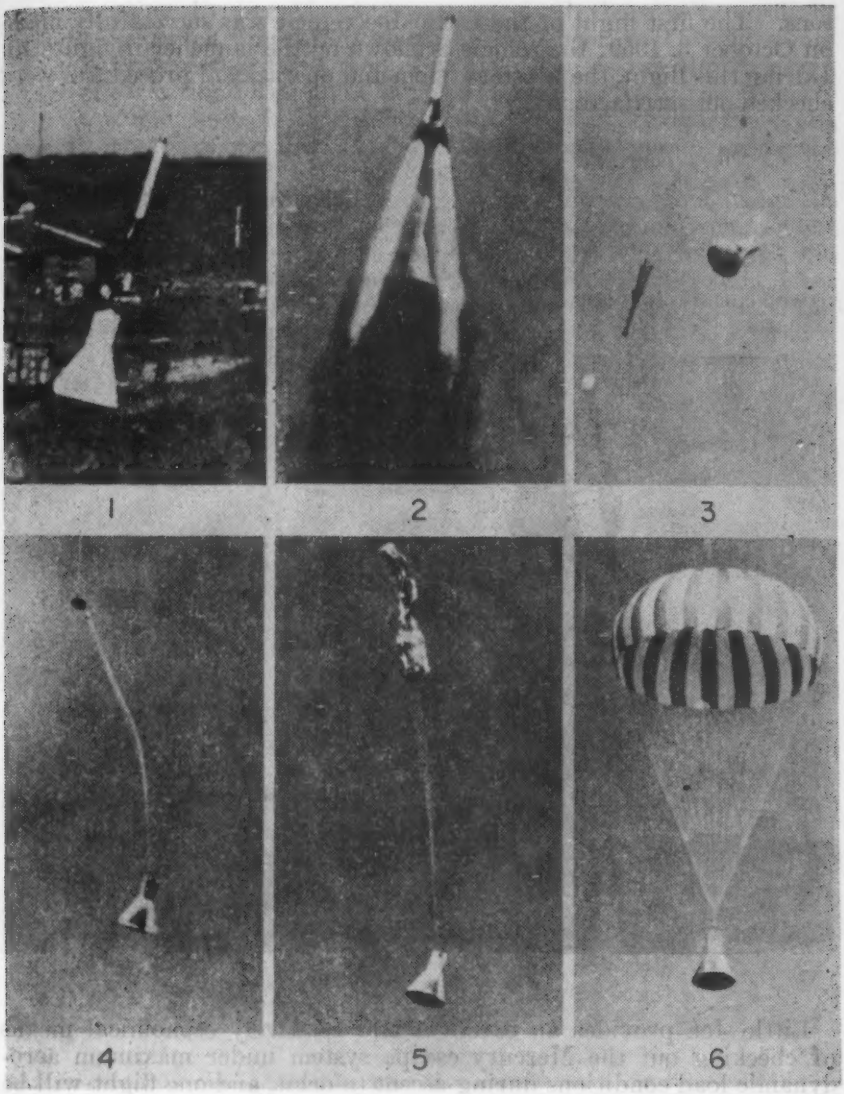


FIGURE 9.—*Off-the-pad abort shot at Wallops Island using Langley PARD designed full-scale capsule with Recruit rocket and extended skirt main parachute.*

Little Joe full scale flight tests

The Little Joe vehicle was conceived as a relatively low cost test vehicle for propelling unmanned test capsules to moderate velocities at near orbital altitudes. In contrast with the other booster vehicles in the Mercury program, the Little Joe booster was developed specifically for the Mercury program. Little Joe consists of a cluster of four large solid propellant Pollux or Castor rockets and four smaller Recruit rockets. The booster is fin-stabilized and weighs about 15

tons. The first flight of the Little Joe vehicle was successfully made on October 3, 1959; the vehicle is shown on the launcher in figure 10. During this flight, the booster system and operational procedures were checked out satisfactorily.

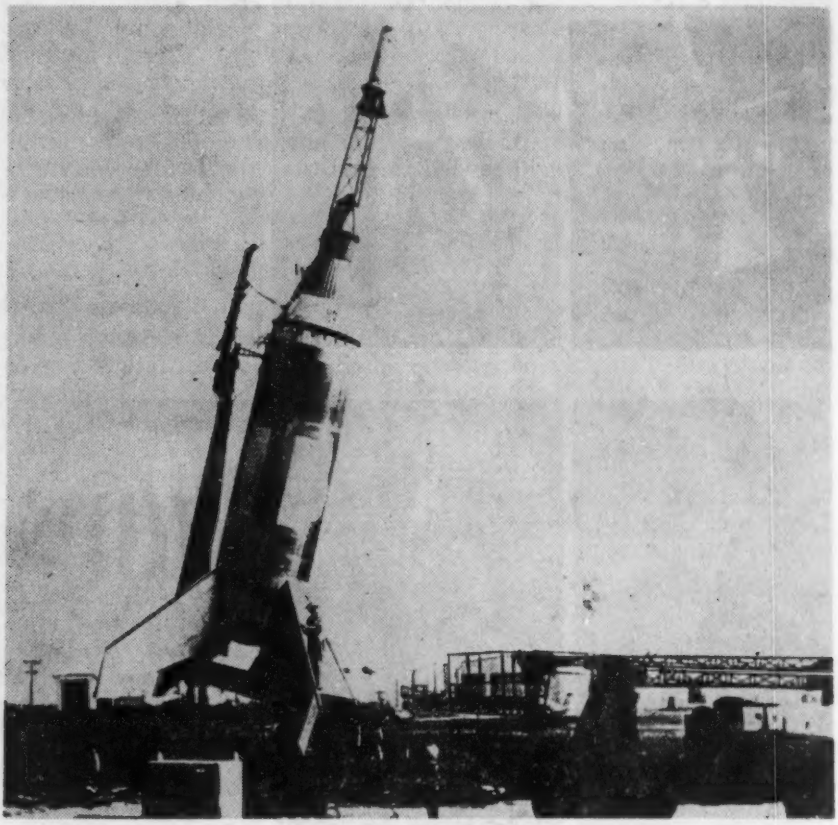


FIGURE 10.—*Little Joe.*

Little Joe provides an excellent and relatively economical means of checking out the Mercury escape system under maximum aerodynamic load conditions during ascent to orbit, and one flight will be made for this purpose. Additional Little Joe flights are planned in order to investigate the abort system characteristics under high altitude conditions. In addition, the Little Joe vehicle will be used to check capsule reentry stability under abnormal conditions, and will be used to check conceptual and engineering design of the parachute, landing, and reentry systems. A total of four Little Joe developmental flights are planned. As will be discussed later, the Little Joe vehicle is also utilized in the qualification program.

The Little Joe program is being managed by the Langley Research Center of NASA and the vehicles are launched from Wallops Island by NASA personnel. North American Aviation and Thiokol Chemical Co. are the major contractors on this program.

Big Joe reentry test

At the time Project Mercury was conceived, there were no flight test results which would indicate that an ablation heat shield would adequately protect a large reentry vehicle such as the Mercury capsule. Fabrication of an ablative spherical surface to fit the Mercury capsule would, in itself, be a difficult feat. It was decided, therefore, to contract for a beryllium heat-sink type shield in addition to the ablation shield.

The beryllium approach required a jettisonable shield technique which would protect the astronaut from heat conduction from the hot beryllium should a land impact occur. During early drop tests from C–130 aircraft, a mockup of the beryllium shield was utilized. After jettisoning, the heat shield tended to foul the capsule afterbody and parachute. This situation gave credence to the ablative approach because the ablation shield does not absorb heat and does not require jettisoning.

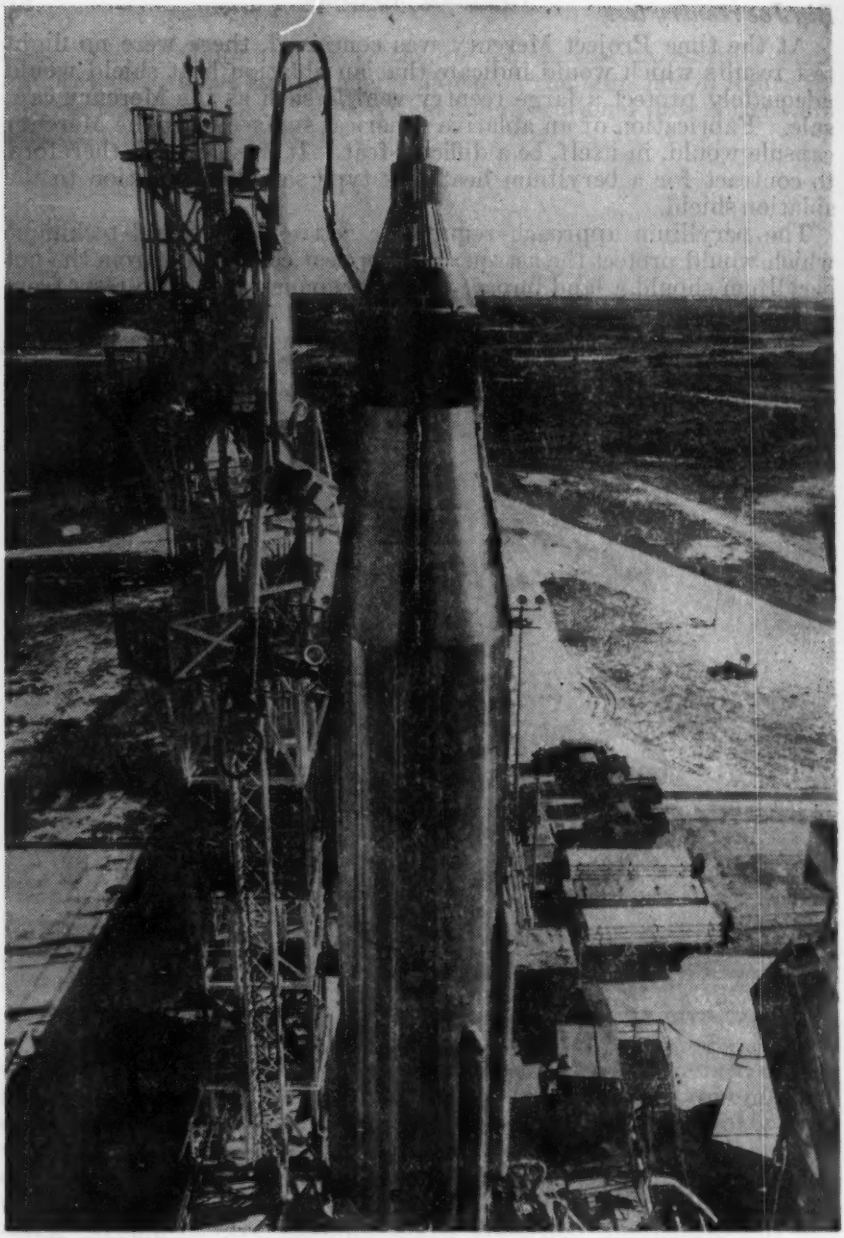


FIGURE 11.—*Big Joe capsule launched with Atlas booster.*

An ablation shield was flown on the Big Joe capsule, figure 12, which was Atlas-boosted to suborbital velocity on September 9, 1959. The Big Joe vehicle and recovered capsule are pictured in figures 11 and 12. The reentry heating rates were nearly the same as those which are expected during the Mercury orbital reentry. The excellent postflight condition of the ablation shield was sufficient proof that this was a sound approach.

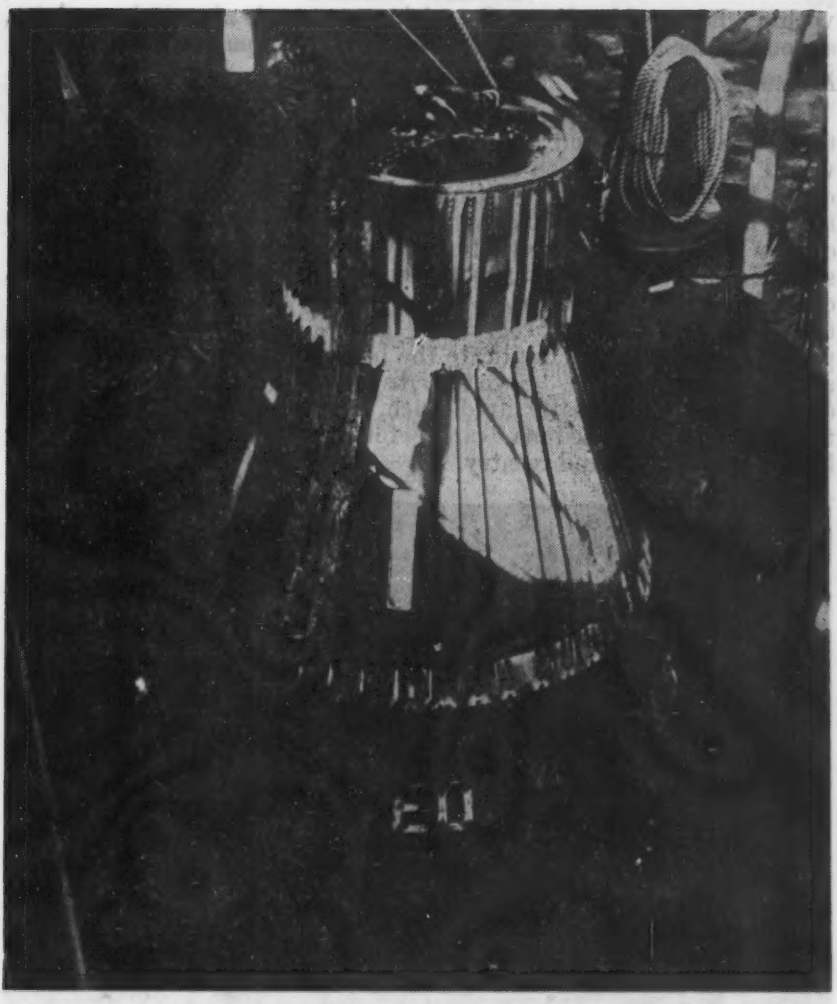


FIGURE 12.—*Recovered Big Joe capsule after flight from Cape Canaveral.*

All the Mercury-Atlas capsules will be equipped with ablation shields. The six beryllium shields which have been fabricated, will be flown on Redstone capsules. The Redstone capsule encounters much less heating because reentry velocity is only one-fourth that of the Atlas capsule.

In addition to the full-scale reentry results, the Big Joe flight provided extremely important confirmation of the capsule recovery plan. A booster malfunction caused the capsule to land several hundred miles short of the planned recovery area. However, the recovery beacon and visual recovery aids in the capsule together with the predicted impact locations, enabled aircraft sighting of the capsule

within 3 hours of landing. Sea pickup was made about 5 hours later, as soon as the nearest ship could steam to the impact area.

Pilot support system

At the outset of the Mercury program, there was considerable doubt that a man could stand the acceleration and deceleration forces that would be associated with ICBM boost to orbital velocity and subsequent reentry. The form-fitting couch (fig. 13) was conceived as a means of allowing man to absorb the loads involved. Extensive runs on the United States Navy Human Centrifuge at Johnsville, Pennsylvania, proved that man, with the aid of the form-fitting couch, could indeed withstand the loads involved, without ill effects. With the aid of appropriate programing devices on the centrifuge, it was possible to completely duplicate the boost and reentry accelerations, as they vary with time. Several individuals, including the astronauts each with his individually fitted couch, have successfully demonstrated that a properly trained man can perform control functions under the high loads of boost and reentry.

FIGURE 13.—*Mercury support couch.*

Qualification program

The previous discussion described efforts that are going into the development of certain components of the Mercury system. All of this development effort culminates in final design or specifications for the operational Mercury system and its components. These Mercury components and the complete system must then be qualified before

manned flight is undertaken. The objective of the qualification program is to see that all hardware items possible be subjected to, and their operation proved in, those environments to which they will be subjected in both normal and emergency conditions for orbital flights. The qualification program encompasses the following major phases:

Static firing test of Redstone booster with capsule on board.
Altitude wind tunnel test of booster-capsule separation system.
Solid-fuel boosted (Little Joe) flight.
Redstone flight program.
Atlas flight program.

The Little Joe, Redstone, and Atlas qualification vehicles are illustrated in figure 14. In addition to these major phases of the qualification program, each capsule system and subsystem will be thoroughly qualified in ground tests; further airplane drop tests and beach abort tests are also planned to qualify the final production escape and landing systems.

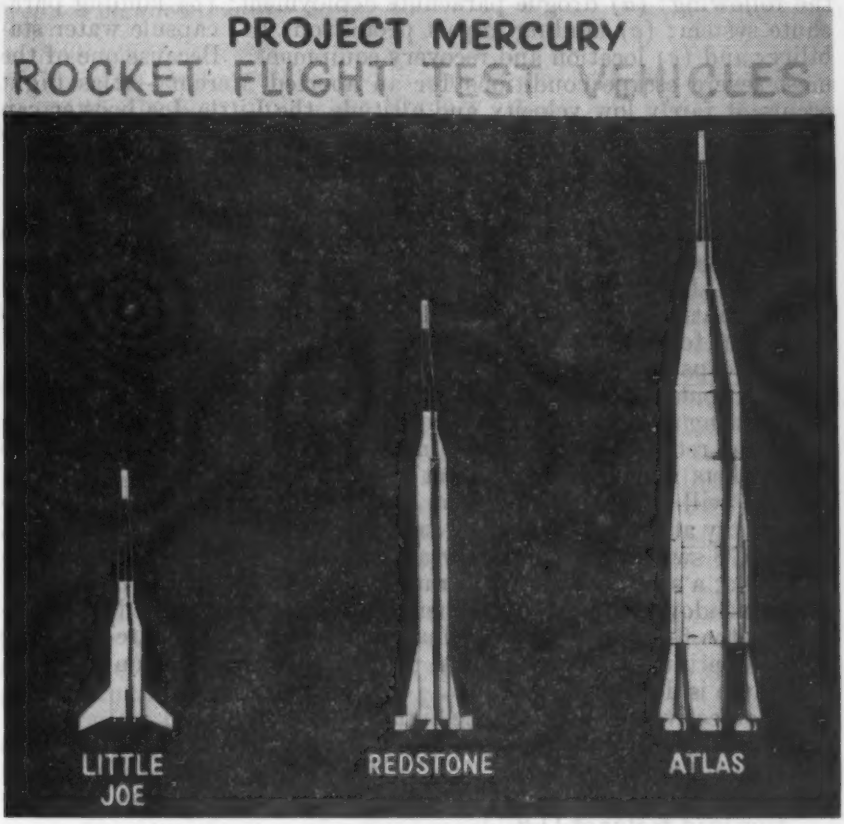


FIGURE 14

Initially, the qualification program also included balloon-launched and Jupiter-boosted flight tests. These phases of the program were eliminated when it became apparent that the objectives of each could be met more expeditiously by other means.

1. Static firing test of Redstone booster with capsule on board

The primary objective of this test is to confirm that the developed capsule systems will operate satisfactorily under booster firing conditions. Extensive vibration and noise measurements will be made during this test, which will be conducted at ABMA.

2. Altitude wind tunnel test of capsule-booster separation

The primary purpose of this test is to confirm the satisfactory separation of the capsule from the Atlas booster. The Lewis Research Center altitude wind tunnel will allow a full-scale evaluation with actual flight components.

3. Solid-fuel booster (Little Joe) flight

The previously described Little Joe booster will be used to confirm satisfactory operation of the developed capsule escape system under the most severe conditions anticipated for an escape from a Mercury-Atlas orbital mission. The flight will also serve to qualify, in part, the following: (*a*) drogue parachute deployment; (*b*) landing parachute system; (*c*) landing impact protection; (*d*) capsule water stability; and (*e*) location and recovery equipment. Because one of the most severe escape conditions for an aborted Mercury-Atlas flight occurs at fairly low velocity and altitude, the Little Joe booster can be used for this test, rather than an appreciably more costly Atlas or Redstone.

4. Redstone flight program

The Redstone ballistic flights will use McDonnell production-type Mercury capsules. All flights will follow identical ballistic trajectories. Escape pylon separation will occur at booster cutoff; capsule separation will be programed to occur 10 seconds after cutoff to allow time for rocket motor tailoff to occur.

After capsule separation from the booster, the automatic stabilization and control system (ASCS) will orient the capsule into the normal orbiting attitude. Before apogee, the retrograde timer will command the retrograde attitude. In some of the Redstone flights, the retrorockets may then be fired at apogee. After apogee, the retropackage will be jettisoned. The ASCS then orients the capsule to the reentry attitude. When the axial load factor builds up to 0.05 g., the ASCS switches from reentry attitude hold mode to a rate-damping mode; a small constant-roll rate is commanded at this time to reduce touchdown dispersion. When the velocity has been reduced sufficiently, the 6-foot drogue parachute is deployed. The rate-damping system continues to operate down to 10,000 feet, whereupon the main parachute is deployed.

The objectives of the Redstone flights are as follows:

(*a*) Qualify the capsule-booster combination during the boost phase of flight.

(*b*) Qualify the capsule during reentry at maximum deceleration load factor of 11 g.

(*c*) Qualify the retrorocket after short periods of weightless flight in space environment.

(*d*) Qualify, in part, the operation of the parachute system, attitude control system, horizon scanner, and other major components.

(*e*) Qualify the recovery system.

(*f*) Obtain experience in the launching, tracking and recovery phases of operation.

(*g*) Qualify the environmental control system and aeromedical instrumentation by the use of animals.

(*h*) Obtain statistical data on an animal-in-space environment.

(*i*) Familiarization and training of astronauts to the boost phase of a missile, to a 5.5-minute period of weightlessness, and to reentry g forces after weightlessness.

(*j*) Evaluation of a man as a functional unit in a space vehicle.

The Redstone develops approximately 75,000 pounds of thrust; has a range of about 150 miles; and has a speed of about 4,000 miles an hour.

In order to meet these objectives, it is planned to first launch an unmanned capsule with a Redstone booster. Later on, the Mercury capsule will be qualified in Redstone flights using animals. When warranted by systems reliability, the Redstone booster will then be used for manned training flights.

5. Atlas flight program

The Atlas booster will be used in a number of ballistic flights before its use as a booster to place the Mercury capsule into orbit. The following flights are contemplated:

(*a*) Ballistic flights to a velocity of about 16,000 feet per second to simulate the most severe escape condition that could be encountered in a planned orbital flight. These flights will qualify the capsule under the maximum load factors possible in any Mercury mission; partially qualify the escape system; and exercise the ground-handling, launch, tracking, and recovery procedures.

(*b*) Ballistic flights to a velocity of about 25,000 feet per second to qualify the capsule under maximum heating loads and to check the procedures for the longest range abort conditions possible. These flights will qualify the booster-capsule combination for exit flight and the capsule for entry flight; they will qualify the recovery equipment and exercise ground-handling launch and recovery procedures. The 25,000-feet-per-second ballistic flights will also qualify the emergency retrograde procedure for orbit abort; partially qualify the environmental control and support system; qualify the booster-guidance system for orbital insertion capability.

None of the Atlas ballistic flights will be manned. However, animals may be used in some of these flights in order to exercise the environmental control system and to obtain data on the reaction of animals to the exit, weightless, and reentry conditions.

Following the completion of the ballistic flight testing program, the Atlas booster will be used to launch the Mercury capsule into orbit. A number of orbital flights, with and without primates, will be used for the following purposes:

(*a*) Qualification of orbital capability of capsule.

(*b*) Qualification of recovery from orbit of capsule.

(*c*) Qualification of worldwide communications and tracking facilities.

(*d*) Exercise of ground-handling, launch, guidance, tracking, and recovery procedures.

(*e*) Determinations of animal's reaction in orbit.

(*f*) Qualification of life-support systems in orbital environment.

(*g*) Partial qualification of body support and protection methods.

The Atlas booster is the result of the cooperative development of the Air Force and its ICBM contractors, principally Convair.

The Atlas booster is uniquely characterized by its 1½-stage configuration and its full monocoque stainless steel structure. Its propulsion consists of three North American Aviation Rocketdyne engines, two boosters of 150,000 pounds thrust each, and a sustainer of 60,000 pounds thrust. There are two vernier engines, each producing 1,000 pounds of thrust, for roll and velocity vector control. All engines burn liquid oxygen and RP–1, a kerosene-like hydrocarbon.

All engines are started at launch, thus avoiding necessity of a start in flight, with corresponding increase in reliability. The booster engines and associated equipment are jettisoned at staging, providing a substantial weight reduction. The sustainer burns continuously until burnout.

Atlas' advanced staging and structural techniques give this booster optimum performance and, principally, operational simplicity resulting in maximum reliability. These features have been proven in actual practice. The design, though advanced in concept, has achieved maturity through a strenuous test-flight program approximating 43 firings with a preponderance of successes. This is particularly true for the last 15 firings, all of which have been successful.

6. Manned orbital flight

Following the successful completion of the program up to that point, the first manned orbital flight will take place. It is planned that this flight will be of a three-orbit duration. Plans for subsequent manned orbital flights will, of course, be influenced greatly by the results of the first successful manned flight. However, a prime objective of additional flights will be to broaden the base of human experience in orbit and to compare the observations, reactions, and capabilities of several different astronauts in a space environment.

The orbital flights will require a worldwide tracking, communications, and recovery network, which will be described in the following section.

PART IV

TRACKING, COMMUNICATIONS, AND RECOVERY NETWORK

Three orbit mission

In the Mercury mission, man and machine together will, for the first time, be subjected to a space and weightless environment. It will, therefore, be desirable to keep the number of orbits on initial flights to a minimum. On the other hand, it will be highly desirable to allow sufficient time for precision orbit determination in order to specify the correct retrofire point for a landing within the desired area. With these criteria in mind, a maximum of three orbits was chosen for the first manned orbital flight.

Launch azimuth considerations

A number of considerations were taken into account to determine the most desirable launching azimuth. These were:

(1) Use of existing tracking stations throughout the world.

(2) Use of the Atlantic Missile Range as the launch area and impact area after the third orbit.

(3) An orbit which remained over the continental United States for a considerable portion of its flight, allowing continuous tracking, both during the orbital flight and during reentry.

For these reasons, a northeast launch from Cape Canaveral was chosen. As shown in figure 4, the northeast launch which was selected results in an orbital inclination of 32½°.

Communications and tracking station locations

The first orbit passes just south of Bermuda, south of the Canary Islands, and across Africa, over the Indian Ocean, and over the Australian Missile Range at Woomera. The track then passes across the Solomon and Phoenix Islands. The orbit then intersects the Mexican and southern California coast, passing over the southern United States where a number of available tracking sites already exist, such as the Pacific Missile Range, the White Sands Proving Grounds, and Eglin Air Force Base, as well as the Cape Canaveral complex. The third orbit passes within close proximity of Hawaii, a very desirable location for radar tracking and command of the retrotimer, since direct hard-line communication is available from Hawaii to the continental United States.

In making the choice of the number and location of the various ground stations, a number of other criteria were established. These included:

(1) The desire to have continuous tracking from Cape Canaveral through Bermuda for accurate orbital determinations, and to have real-time telemetry and continuous voice contact during this time.

(2) The ability to reset the retrotimer conveniently on each orbit, as well as having direct ground command of the retrofiring during each orbit.

(3) The need for continuous contact with the capsule during launch and a reasonable length of time following orbital insertion.

(4) A desire to maintain frequent voice and telemetry contact with the capsule.

(5) The need for continuous impact prediction in case of an early abort requiring impact in the Atlantic Ocean, or during an early reentry if an emergency should occur after orbit injection.

All of these and many other requirements, based on practical and economic limitations, resulted in the stations as indicated in fold-in map. A number of these stations have command capability as well as accurate radar equipment. The stations transmit tracking data to a central computing facility to be located in Washington, D.C. The operation control center is to be located at Cape Canaveral. All of the computed trajectory data, telemetry data, and other forms of communications, whether it be real-time or teletyped summary data, will be funneled through the Cape Canaveral Control Center. The data will be presented there in a number of ways to allow immediate decisions to be made regarding the status of the flight.

Control center

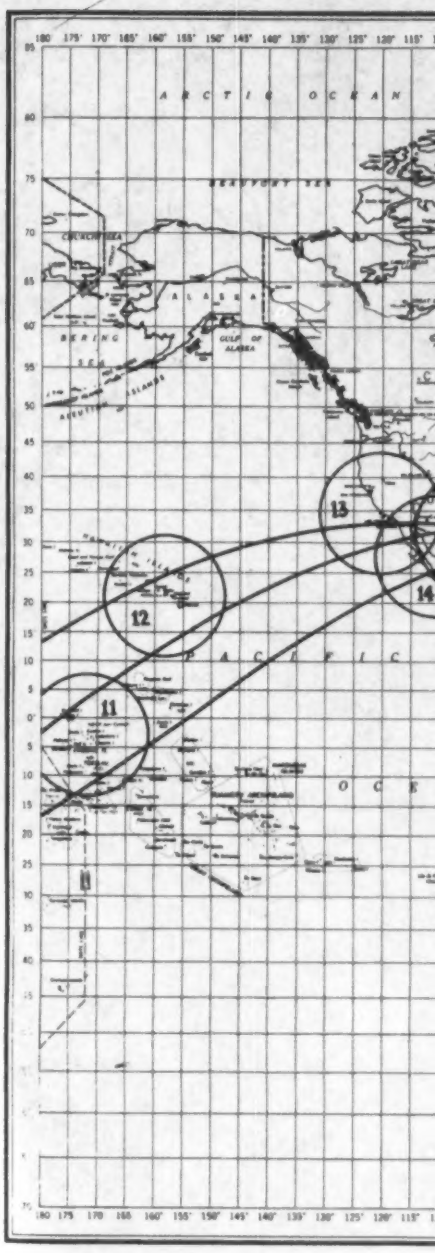
The control center is to be the focal point for the entire operation and, as noted previously, will be the location where all of the necessary decisions affecting the flight are made, with the exception of certain extreme emergency conditions. The primary functions of the center are to—

1. Direct all aspects of the flight including booster launch, orbital, and reentry phases.
2. Monitor the flight from both an aeromedical and capsule-system status point of view.
3. Make decisions to abort the mission based on orbital characteristics and capsule status.
4. Determine the proper procedures following abort decisions.
5. Command reentry in both normal and emergency conditions.
6. Keep the astronaut and range stations informed of mission progress.
7. Coordinate all of the range stations and maintain a smooth flow of information to all of the units involved in the operation.
8. Supply information and alert the recovery forces following a decision to start the reentry maneuver.

In order to accomplish this task, it is obvious that a great amount of data and information must be disseminated at the control center and presented in a form that will allow rapid decisions to be made.

Redundant tracking and computing facilities during launch

Because of the critical period during launch and orbital insertion, additional computing facilities other than those at Washington, are required at Cape Canaveral and at Bermuda. The General Electric guidance and the Burroughs computing systems will be the primary source of information for the Cape Canaveral Control Center, since it is this system which performs the guidance function of the Atlas



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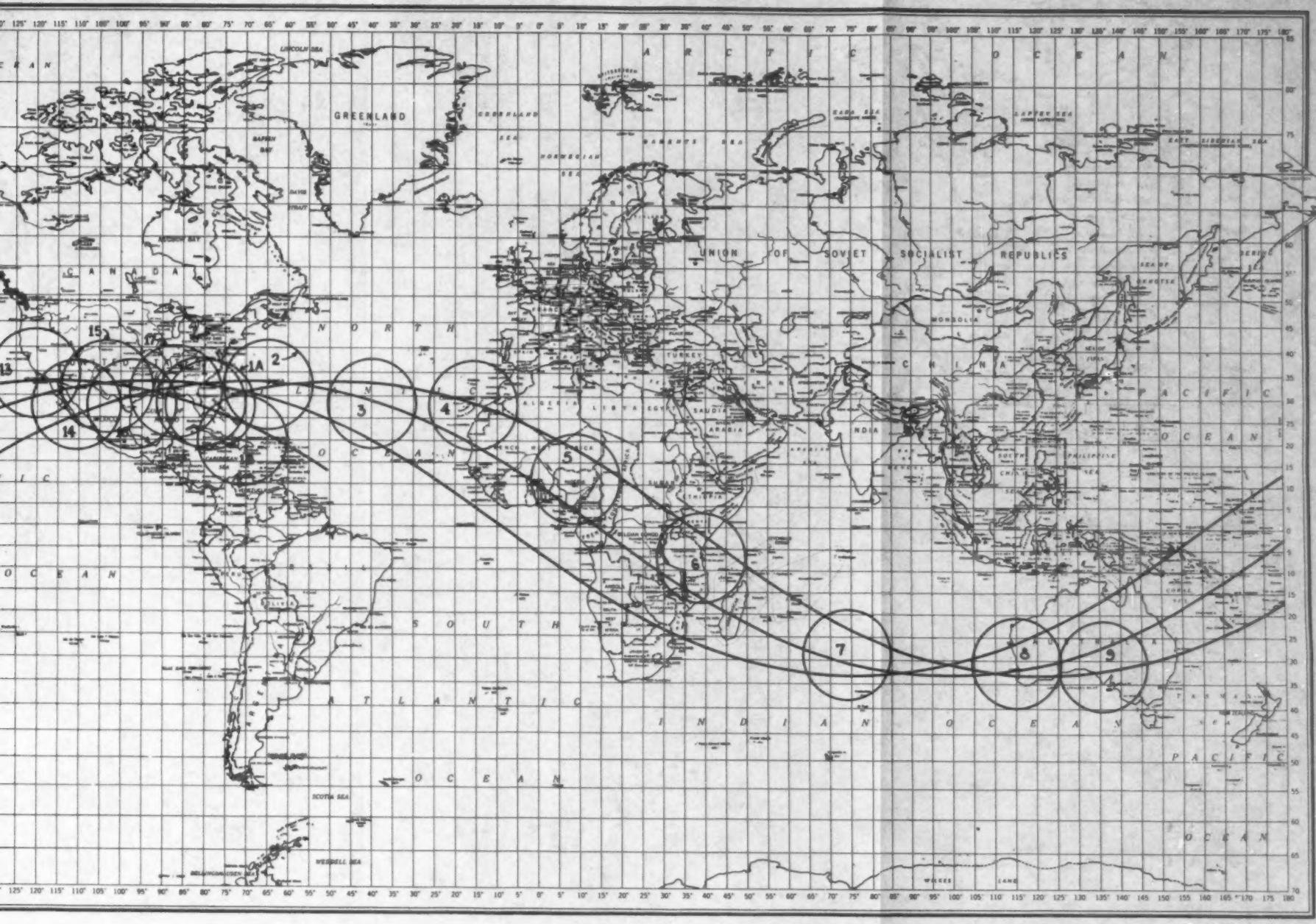

STATION LEGEND

1. CAPE CANAVERAL	4. GRAND CANARY ISLAND	9. WOOMERA, AUSTRALIA	14. WEST MEXICO
1A. GRAND BAHAMA	5. KANO, NIGERIA	11. CANTON ISLAND	15. WHITE SANDS
1B. GRAND TURK	6. ZANZIBAR	12. HAWAII	16. SOUTH TEXAS
2. BERMUDA	7. INDIAN OCEAN SHIP	13. SOUTHERN CALIFORNIA	17. EGLIN (AFATC)
3. MID ATLANTIC SHIP	8. WEST AUSTRALIA		

LOCATION OF STATION

missile. These data will be used to calculate the launch trajectory and orbital insertion parameters which are to be displayed. Also, since this is the critical phase of the mission, the Azusa and FPS–16 radar systems at Cape Canaveral will provide backup information for the same displays in the control center should a malfunction of the Atlas ground guidance system occur. This redundancy is necessary since information on the capsule position and velocity will be required in order to make the proper abort decisions if a guidance failure occurs.

A very high-reliability radio communications system between Cape Canaveral, Washington, and Bermuda must be provided to transmit real-time trajectory data. However, because of the inability to provide a 100-percent reliability factor and the absolute necessity of making important command decisions at Bermuda, it is necessary to provide redundant computing facilities at that site. The FPS–16 radar data at Bermuda will be passed through the computer to provide the trajectory displays.

General description of tracking and ground instrumentation systems

The tracking and ground instrumentation systems for Project Mercury will consist of 18 ground stations, a computing and communications center, and a control center, illustrated in the fold-in map. Of the 18 ground stations, 11 will be equipped with long-range precision radars and will comprise the tracking system. Sixteen of the stations will be equipped with telemetry receivers. All stations will be linked with the computing and control centers by a communications network. Major equipment at the individual stations is listed in table 1 on page 44.

Eight of the 18 stations and the control center will be located on military missile ranges where use will be made of existing radars and other facilities. At these locations, a major part of the required equipment, including most of the tracking radars, is now in existence and will be made available for this project. (These locations involve the Department of Defense missile test facilities and the Commonwealth of Australia.) NASA will arrange for the use of this equipment. At the remaining 11 locations, new equipment and facilities are required.

One new station will have to be established in the United States, two stations will be located on shipboard, and seven on foreign territory. The computing and communications center will be located at the Goddard Space Flight Center near Washington, D.C.

TABLE 1.—*Major equipment at individual stations*

Station	Location		Long-range S-band radar	C-band radar	Telemetry and communications with capsule	Ground communications				
	Latitude (degrees)	Longitude (degrees)				Command control	Teletype	High-speed data transmitter	Voice	Computing
Cape Canaveral (AFMTC)	28.46 N	80.56 W	----------	⊠	X	⊠	X	X	X	----------
Grand Bahama	26.65 N	78.37 W	----------	----------	X	⊠	⊠	⊠	⊠	----------
Grand Turk	21.48 N	71.13 W	----------	----------	X	⊠	⊠	⊠	⊠	----------
Bermuda	32.35 N	64.66 W	X	X	X	X	X	----------	X	X
Mid-Atlantic ship	28.00 N	40.00 W	----------	----------	X	----------	X	----------	----------	----------
Grand Canary	27.73 N	15.60 W	X	----------	X	----------	X	----------	X	----------
Kano, Nigeria	11.58 N	8.28 E	----------	----------	X	----------	X	----------	----------	----------
Zanzibar	6.00 S	39.33 E	----------	----------	X	----------	X	----------	----------	----------
Indian Ocean ship	28.40 S	73.70 E	----------	----------	X	----------	X	----------	----------	----------
West Australia	31.60 S	115.93 E	X	----------	X	X	X	----------	X	----------
Woomera, Australia	31.20 S	137.10 E	----------	⊠	X	----------	X	----------	X	----------
Canton Island	2.79 S	171.67 W	----------	----------	X	----------	X	----------	----------	----------
Hawaii	22.16 N	159.63 W	⊠	⊠	X	⊠	X	----------	X	----------
Southern California	34.58 N	120.58 W	⊠	⊠	X	⊠	X	----------	X	----------
West Mexico[1]	28.00 N	110.83 W	X	----------	X	X	X	----------	X	----------
White Sands	32.36 N	106.37 W	----------	⊠	----------	----------	X	----------	X	----------
South Texas	27.65 N	97.23 W	X	----------	X	----------	X	----------	X	----------
Eglin (AFATC)	30.45 N	86.80 W	⊠	⊠	----------	----------	X	X	X	----------
Computing and Communications Center, Washington, D.C.	----------	----------	----------	----------	----------	----------	X	X	X	X
Control Center, Cape Canaveral (AFMTC)	----------	----------	----------	----------	----------	----------	X	X	X	X

[1] Negotiations with Mexico are underway to obtain permission to establish this station.

NOTE.—The NASA will arrange for the use of equipment marked ⊠.

Major functions of each station

A. Functions of tracking and ground instrumentation systems.—The tracking and ground instrumentation systems will provide all the functions necessary for ground control and monitoring of the flight from insertion to landing.

The Air Force Ballistic Missile Division (by agreement with NASA) will have the general responsibility for the Atlas vehicle and placing the capsule in the required orbit. NASA–AFBMD will be responsible for making arrangements at the Air Force Missile Test Center for the launch phase and will be responsible for the vehicle propulsion and guidance during launch and through insertion. During this period the Mercury Control Center shall monitor the operation and render decisions regarding the capsule and its occupant.

From insertion to landing, the tracking and ground instrumentation systems will provide continuous prediction of the location of the capsule; will monitor the status of the vehicle and occupant; and will permit the exercise of the command functions necessary for the mission.

The functions of the tracking and ground instrumentation systems are completed when the capsule has landed and the best possible information on the location of landing point has been supplied to a recovery team. It is planned that the recovery operation will be a joint effort of the military services under cognizance of the U.S. Navy.

B. Major functions of stations described.—1. *Cape Canaveral, station 1; Grand Bahama Island, station 1(a); Grand Turk Island, station 1(b).*—The functions to be performed at stations 1, 1(a), and 1(b), as discussed herein, involve several locations in the AFMTC complex for tracking, telemetry, and vehicle communications. It is necessary to utilize equipment at Cape Canaveral, Grand Bahama Island, and Grand Turk Island. The use of Cape Canaveral and Grand Bahama is required during launch because of look-angle problems and the associated capsule antenna patterns. Grand Turk is needed to provide coverage during the final phase of reentry where altitude limits the range of the stations.

From prelaunch through insertion, continuous telemetry, voice communications, and command capability will be provided to the control center and tracking data will be transmitted to the computing center.

(During this same period AFMTC–AFBMD will make other data available to the Mercury Control Center and will provide acquisition data and insertion parameters from the Atlas guidance system to the computing center and to Bermuda. These data are separate from the function of station 1 as discussed herein.)

During successive passages, the station will provide tracking by telemetry, and voice communication coverage. Command capability is also necessary in order to permit resetting the retrofiring programer and to furnish command backup of certain internally programed events during reentry and landing.

2. *Bermuda, station 2.*—The Bermuda station will have the capability to determine if the capsule has been placed into an acceptable orbit and to effect an abort landing in one of the major recovery areas if the trajectory is not acceptable. Tracking, computing, telemetry, and command equipment will be provided with the capability to per-

form this function essentially independent of data from the launch site.

Other functions may be as follows:

(*a*) To command an abort at the direction of the control center in the event of serious capsule equipment failure or pilot difficulty late in the launch phase.

(*b*) To command an abort as directed by the control center for impact in a major recovery area in the event of certain propulsion or guidance system malfunctions.

(*c*) If the flight is normal, tracking and data transmission to the computing center will be required.

(*d*) If the flight is not normal, the impact point will be computed for use by the search and recovery group.

After a successful insertion, the Bermuda station must provide normal tracking and vehicle communications on successive passes. The station must also transmit commands to reset the retrofiring timer as directed by the control center. In the event of an emergency landing at the end of the first or second passage, tracking and computation of the landing point are required.

3. *Mid-Atlantic ship, station 3.*—This station will provide telemetry and voice communications coverage in the area of the mid-Atlantic on all three passes.

The equipment required for this station will be placed aboard a Government-furnished C1–M–AV1 ship.

4. *Grand Canary Island, station 4.*—This station will provide normal tracking, telemetry, and voice communications coverage for the first and second passes in the general area of northwest Africa. In the event the mission is aborted near the insertion point, the station will provide reentry tracking and landing location for the northwest Africa recovery area. This station will provide data on landing location directly to the local recovery team.

5. *Kano, Nigeria, station 5.*—This station will provide normal telemetry and voice communications coverage on passes 1 and 2 in the general area of central Africa.

6. *Zanzibar, station 6.*—This station will provide normal telemetry and voice communications coverage on passes 1 and 2 in the general area of central Africa.

7. *Indian Ocean ship, station 7.*—This station will provide telemetry and voice communications coverage in the area of the mid-Indian Ocean on all three passes. The equipment required for this station will be placed on board a Government-furnished C1–M–AV1 ship.

8. *West Australia, station 8.*—This station will provide tracking, telemetry, and voice communications coverage on all three passes of a normal mission and transmit command functions as required. Tracking data obtained at this point in the orbit, which is approximately 180° from the point where insertion data are obtained, will give maximum residuals and provide for rapid refinement of orbital parameters.

If an emergency landing is required at the end of the first orbit, the Australian station will be instructed from the control center to reset the capsule timer for firing of retrorockets at the proper time to ini-

tiate, reentry and landing into the recovery area off the east coast of the United States and the recovery area near Bermuda.

9. *Woomera, Australia, station 9.*—The Woomera location will provide C-band tracking, telemetry, and voice communication coverage on orbits 1 and 2. The NASA will make arrangements with the Weapons Research Establishment for operation and use of an FPS–16 radar located at Woomera. The contractor will provide certain additional equipment for this station and deliver it to personnel of the Weapons Research Establishment at an Australian port of entry.

10. *Canton Island, station 11.*—This station will provide normal telemetry and voice communications coverage on passes 1 and 2.

11. *Hawaii, station 12.*—The function of this station is to provide tracking, telemetry, and voice communications on passes 2 and 3 and to transmit command functions as required. This station also maintains voice communications with the control center.

The NASA will make arrangements for the use of an FPS–16 radar which is programed by the Pacific Missile Range for the installation on the island of Kauai.

12. *Southern California, station 13.*—The function of this station is to provide tracking, telemetry, and voice communication coverage for passes 2 and 3 to transmit command functions as required. The station also maintains voice communications with the control center. This station provides the first tracking data after reentry initiation on passes 2 or 3. Telemetry data received will indicate whether the reentry initiation retrorockets have been fired at the programed time. If not, this station will command retrofiring to initiate reentry.

NASA will make arrangements for the use of an FPS–16 radar and other existing equipment already in use by the Pacific Missile Range at this station.

13. *West Mexico, station 14.*—The function of this station is to provide tracking, telemetry, and voice communications coverage for passes 1 and 2 and to transmit command functions as required. The station also maintains voice communications with the control center. This station provides the first tracking data after reentry on pass 1. Telemetry data received will indicate whether the reentry initiation retrorockets have been fired at the programed time. If not, this station will command retrofiring to initiate reentry. At the time of this report, Mexico had not granted the United States permission to establish this station. If permission is not obtained, the functions of this station will be accomplished by using a ship stationed offshore of Mexico.

14. *White Sands, station 15.*—This station contributes to the continuous tracking coverage in the United States on all three orbital passes, using an existing FPS–16 radar at White Sands.

15. *Southern Texas, station 16.*—The station in southern Texas provides tracking, telemetry, and voice communication for all three passes and contributes to continuous coverage of the reentry trajectory.

16. *Eglin (AFATC), station 17.*—The function of this station is to contribute to continuous tracking coverage in the United States on all orbital passes. Data transmission is required from Eglin to AFMTC to extend the reentry trajectory plot at the Mercury control center. Teletype tracking data will be sent to the computing center. NASA

will use an existing FPS–16 radar and MPQ–31 S-band radar at this station.

17. *Computing and communications center, Goddard.*—The computing and communications center will be located at the Goddard Space Flight Center, Beltsville, Md. The Government will make available building space for the Goddard location. The primary functions of the computing and communications center will include:

(*a*) During orbital flight, the center will compute and transmit to the required stations the following information: (1) Parameters describing the trajectory, (2) the predicted location of the capsule, (3) the predicted location of impact for emergency reentry, (4) time to fire retrorockets to land in next recovery area, and (5) time to fire retrorockets to accomplish a normal landing.

(*b*) During reentry, the center will provide and transmit to the control center continuous prediction of the landing point on essentially a real-time basis.

(*c*) Throughout the entire operation, the center will provide acquisition information to all field sites.

(*d*) The center will serve as the main communications terminal for the Mercury operations. Communications to all field sites will pass through the center's communication area, and the appropriate switching and monitoring facilities will be provided.

18. *Control center, Cape Canaveral (AFMTC).*—An existing building at AFMTC, presently equipped with air conditioning and primary power, is to be used for the control center. Necessary building alterations will be made and necessary equipment will be designed and installed.

The function of the control center will be to provide control and coordination of all activities associated with the Project Mercury operation. The necessary communications, displays, and control equipment will be provided to perform the following basic functions:

(*a*) Coordination with AFBMD–AFMTC complex during launch, including monitoring of vehicle propulsion and guidance, and assistance on range safety.

(*b*) Control of all stations outside AFMTC complex.

(*c*) Monitoring of pilot and capsule systems.

(*d*) Instructions to pilot.

(*e*) Inflight trajectory monitoring.

(*f*) Commands to capsule equipment.

(*g*) Initiate normal reentry and landing.

(*h*) Initiate emergency landing at completion of first or second passage.

(*i*) Initiate emergency aborts.

(*j*) Supply landing location information for search and recovery team.

PART V

OPERATIONAL CONCEPT

Prelaunch countdown

The Mercury operation will start with the normal missile and capsule countdown, with proper monitoring from the control center and blockhouse. The necessary displays for aeromedical and capsule systems checkout will be provided in appropriate trailers and in the blockhouse for monitoring until lift-off of the missile. All of the range stations and the recovery units will be alerted and a check will be made to assure their proper operation and their readiness. At about an hour before launch, the astronaut will board the capsule with the assistance of the capsule checkout team. After the astronaut is aboard and the capsule is properly sealed, the countdown will continue with the astronaut taking a continuous part by voice contact with the blockhouse. From this period on, the capsule's escape system is armed so that in case of an emergency involving the booster the escape rocket can be fired by the blockhouse to provide immediate escape. Until lift-off, the command control is solely a function of the blockhouse, although certain hold capabilities will exist in the control center should some pertinent support function develop trouble.

Launch phase

After lift-off, the command responsibilities will shift to the Mercury control center and all decisions throughout the flight will originate from this point. As the powered portion of the flight progresses, continuous observations will be made of the telemetered quantities and voice contact with the astronaut will be maintained.

The Mercury-Atlas differs from the missile versions of the Atlas in that an automatic abort system is installed. The automatic abort system will sense engine and guidance failures, and, if necessary, shut down the engines and automatically fire the capsule's escape system. If during the launch certain of the capsule systems do not function properly, the pilot has the backup capability of manually adjusting the system controls or of correcting any sequence malfunction. After lift-off, the first critical point to be reached is the staging of the Atlas missile. Twenty seconds after staging, the capsule escape tower is released and the escape and jettison rockets are fired to carry the tower away from the flight path of the missile.

Once the staging process has been completed and the missile is operating satisfactorily on the sustainer engine, continuous attention will be given to the trajectory displays to ascertain that proper guidance of the missile is being accomplished. Here, again, the pilot will be continuously interrogated to confirm that he and the capsule are functioning properly.

As the capsule approaches orbital insertion conditions, one of the most critical phases of the powered portion of the flight exists. Be-

cause of the rapid acceleration of the missile at this time (on the order of 8 g.'s, which corresponds to about 250 feet per second per second) and the very close tolerances in velocity and flight path angle which must be met at this point, very rapid decisions must be made. For this reason, precomputed programs will be incorporated in the high-speed computer to aid in making the proper decisions at this time. Also, since it is impractical to consider all possibilities, visual displays of the pertinent quantities will be presented for a possible decision. These will include altitude versus range, flight path angle versus velocity, and impact predictor plots.

Abort and recovery considerations

Once the decision has been made to either continue the mission or to abort, further decisions must be made regarding the reentry maneuver, which involves certain prescribed recovery areas and the use of capsule retrorockets. Figure 15 shows the location of a number of re-

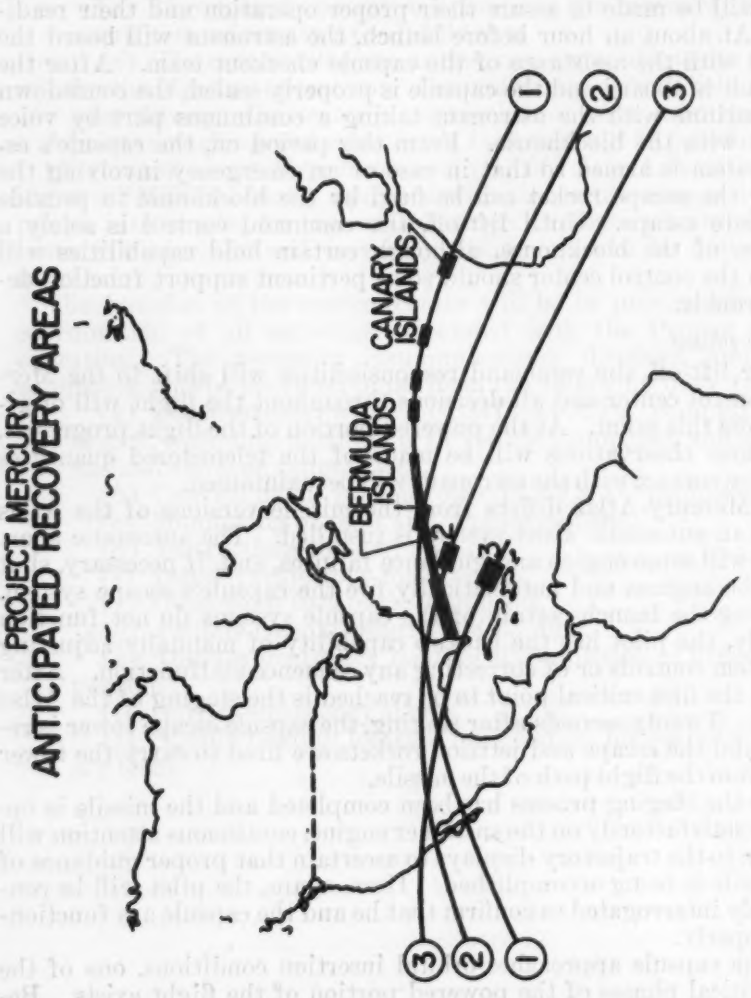

FIGURE 15.—*Project Mercury anticipated recovery areas.*

covery areas to be used in the case of an aborted mission and at the end of any one of the three orbits.

First, consider the case where sustainer cutoff results in an underspeed condition requiring an immediate reentry maneuver. A number of prime recovery areas have been selected between Cape Canaveral and the west African coast to provide rapid access to the capsule. Depending on the velocity at cutoff, computations will be made to determine the proper use of the retrorockets in order to land in one of the recovery areas. If, for instance, cutoff occurs at a velocity only slightly below orbital speed, the computer will indicate that a certain number of seconds following capsule release the retrorockets should be fired in order to bring the capsule down in the last prescribed recovery area.

If the cutoff speed is considerably less than the orbital speed, the time of retrofire after release becomes longer until the capsule speed is such that even without retrofiring this particular recovery area cannot be reached. The next westerly recovery area then comes into play and a time of retrofire is selected to impact in this recovery area. As will be noted, from about 400 to 500 miles beyond Bermuda, the recovery area is continuous back to the Florida coast, since the retrorockets have little effect on the total range of the capsule below a certain speed; the capsule is then allowed to follow the normal ballistic trajectory to impact.

The three other recovery areas shown are for recovery at the end of the first, second, or third orbit. The landing areas under the first and second orbits are provided in the event that burnout conditions dictate this number of orbits or an emergency develops requiring reentry. The philosophy adopted here is that if a malfunction occurs following a successful orbital insertion, enough system redundancy exists to allow the capsule to continue for a period of at least one orbit. Of course, the prerogative of initiating the retromaneuver exists at any time, but because of the extreme recovery problem that may exist, this would be considered as a last alternative.

In all the cases described, a prime consideration is the impact prediction required once the reentry maneuver has been initiated. The recovery areas will be set up to cover certain landing dispersions of the capsule, based on the possible velocity and flight path angle conditions which may exist. However, once these conditions are measured by the ground facilities, it will be possible to predict the capsule impact point very accurately. In all the areas where impact is likely to occur, such ground impact-prediction capabilities will be available and the recovery forces can be directed to the impact point within a given area immediately following the start of the reentry maneuver.

The recovery forces will consist of ships, airplanes, and helicopters. These forces will be deployed in all of the impact areas. The density of the recovery forces will be varied in a manner to permit rapid recovery in high-probability landing areas, and less rapid recovery in areas where a landing is less likely.

PART VI

ASTRONAUT PROGRAM

Pilot responsibilities

Although the primary objective of the Mercury mission is to determine man's capabilities and reactions in a space environment, the inclusion of a pilot will also add reliability to the system. The capsule contains many direct reading instruments and controls which can be monitored by the pilot. He can take action to back up many of the critical automatic functions of the environmental, communications, and control systems. Although much of the systems monitoring is done remotely by telemetry, only the pilot has direct and continuous knowledge of the systems' behavior.

Probably the most important pilot function from the standpoint of reliability is his ability to monitor and back up the various sequences such as escape tower separation, capsule separation, retrofire, retrojettison, drogue chute deployment, main chute deployment, and actuation of the recovery aids. Most of these functions result from electric signals which should be automatically generated by microswitches, relays, timers, pressure switches, accelerometers, or by ground command. These signals then ignite pyrotechnic squibs which fire explosive bolts or solid rockets. Past experience indicates that manual backup of these functions should add materially to overall reliability.

Criteria used in astronaut selection

Many of the engineering or technical requirements of the pilot or astronaut have been mentioned. In many ways the type of decisions and the physical and mental stresses involved are similar to those that confront an experimental-test pilot. For these reasons, it was decided to restrict the volunteers to experimental-test pilots. The following additional criteria were established:

1. Flying experience—1,500 hours.
2. Graduation from a military test pilot school.
3. Bachelor degree or equivalent in engineering or science.
4. Under age 40.
5. Height: 5 feet 11 inches, or less (height was restricted because the diameter of the Mercury capsule limits pilot's size to 5 feet 11 inches in the support couch).

Selection procedure

Personnel records were screened based on the above criteria. Approximately 100 men met these qualifications. In February 1959, two-thirds of this group were briefed on Project Mercury and a high percentage (80 percent) volunteered. Those who volunteered were interviewed and were given advanced aptitude tests. Based on this additional information, 32 men were chosen to proceed to the Lovelace Clinic, Albuquerque, N. Mex., for a thorough medical examination and then to Wright Air Development Center, Ohio, for a week

of physical stress tests. During the stress tests, the candidates experienced accelerations up to 12 g.'s, pressure altitude of 100,000 feet in a partial pressure suit, and high temperature levels.

Although the results of the previously mentioned tests constituted an important part in the selection procedures, the final selections were based primarily on past performance and engineering capabilities in relation to the specific needs of Project Mercury. During the first week in April 1959, seven of the volunteers were notified that they had been chosen as Mercury pilots. These seven men are:

Malcolm Scott Carpenter.
Leroy Gordon Cooper, Jr.
John Herschel Glenn, Jr.
Virgil Ivan Grissom.
Walter Marty Schirra, Jr.
Alan Bartlett Shepard, Jr.
Donald Kent Slayton.

Biographical sketches are on pages 55 to 59.

Engineering activities and familiarization program

The Mercury pilots have been assigned to the following subsystems or specialty areas:

1. Communications and navigation—Carpenter.
2. Control system—Grissom.
3. Cockpit layout—Glenn.
4. Life-support system—Schirra.
5. Tracking and recovery—Shepard.
6. Redstone booster—Cooper.
7. Atlas booster—Slayton.

It is the responsibility of each man to determine if, within his particular area, the system is compatible with manned operation. In addition to work within their specialty assignments, the pilots, as a group, attend lectures on rocket propulsion, space mechanics, gyroscope theory, stable platforms, space navigation, communications, meteorology, astronomy, and physics of the upper atmosphere. These lectures are given by members of the Langley Research Center. The pilots also receive status briefings from the NASA Mercury project engineers.

An important part of the familiarization program involves visits to the various contract facilities. Group visits have been made to McDonnell (capsule), Convair (Atlas booster), Rocketdyne (Atlas engines), ABMA (Redstone booster), and Cape Canaveral (Atlas and Redstone launch facilities). The pilots visit individually the subcontractors within their own specialty areas. During these visits they are briefed on the Mercury systems and on advanced programs which are under study and development.

Simulators

In order to familiarize the pilot with the capsule environment and provide procedural training, several static and dynamic simulators have been scheduled. They are:

(*a*) *Langley analog computer.*—This fixed-base computer gives the pilot practice in controlling the vehicle with the manual control system. A pilot instrument panel contains the actual capsule flight instruments which are driven by an analog computer. Six-

degree-of-freedom equations of motion are programed into the computer. The pilots practice manual control during simulated orbit, retrofire, and reentry.

(*b*) *Langley MB–3 flight simulator.*—This simulator is similar to the previously mentioned analog computer setup; however, the MB–3 simulator also includes an instrument console.

(*c*) *Procedures trainers.*—The procedures trainer is a mockup of the interior of the actual capsule and, in conjunction with the MB–3 simulator, will provide a closed-loop simulation in which the pilot can become familiar with all procedural aspects of normal and emergency missions. A second procedural trainer will be used at Cape Canaveral to provide additional training in range network and launching procedures.

(*d*) *ACEL environmental system trainer.*—A complete life-support system will be placed in the decompression chamber at the Navy, Air Crew Equipment Laboratory in Philadelphia. This trainer will serve the dual purpose of qualifying the environmental control system and familiarizing the pilots with the system's characteristics.

(*e*) *Human centrifuge facilities.*—The human centrifuge facilities at Wright Air Development Center and at the Johnsville Navy Development Center provide familiarization with high acceleration and also give practice in closed-loop control of the capsule during simulated reentry.

(*f*) *Air-bearing attitude simulator.*—A support couch mounted on a low-friction air bearing will be used to familiarize the pilots with the orbital dynamics of the capsule under influence of the reaction-control jets. This simulator is limited to 45-degree rotation in pitch and roll.

(*g*) *Gimballed attitude simulator.*—This simulator, which is located in the altitude wind tunnel at the Lewis Research Center, possesses complete angular freedom in pitch, yaw, and roll and will give the pilots practice in controlling a capsule with severe angular rotation.

(*h*) *Capsule egress trainer.*—A special egress capsule has been fabricated and will be placed in various water conditions for pilot egress practice.

(*i*) *Zero-g flights.*—Flights in specially equipped C–131 and F–100F aircraft are planned which will provide weightless flight for periods of 15 seconds and 1 minute, respectively.

(*j*) *Zero-g water tank.*—A water tank mounted on bearings will be used to determine pilot disorientation under partially simulated zero-g. conditions.

Biographies of Project Mercury Astronauts

Malcolm Scott Carpenter

Malcolm S. Carpenter, a lieutenant in the U.S. Navy, was born May 1, 1925, in Boulder, Colo. He now lives at 11911 Timmy Lane, Garden Grove, Calif. His mother is living in Boulder at 5335 Broadway. Carpenter's father, a retired chemist, lives in Palmer Lake, Colo. His wife is the former Rene Louise Price, whose parents, Mr. and Mrs. Lyle S. Price, live at 963 Ninth Street, Boulder. The Carpenters have four children: Mark Scott, 9; Robyn Jay, 7; Kristen Elaine, 3; and Candace Noxon, 2. Carpenter is 5 feet 10½ inches tall, weighs 160 pounds, and has green eyes and brown hair.

After receiving his early education through high school in Boulder, Carpenter entered Colorado College in 1943 to participate in the V–5 flight training program sponsored by the U.S. Navy. After a year there, he spent 6 months in training at St. Mary's preflight school, Moraga, Calif., and 4 months in primary flight training at Ottumwa, Iowa. When the V–5 program ended at the close of World War II, Carpenter entered the University of Colorado to major in aeronautical engineering. He received a degree there in 1949.

Following his graduation, Carpenter joined the Navy and received flight training from November 1949 to April 1951 at Pensacola, Fla., and Corpus Christi, Tex. He spent 3 months in the Fleet Airborne Electronics Training School, San Diego, Calif., and, until October 1951, in a Lockheed P2V transitional training unit at Whidbey Island, Wash.

In November 1951 he was assigned to Patrol Squadron 6 based at Barbers Point, Hawaii. During the Korean conflict he was engaged with Patrol Squadron 6 in antisubmarine patrol, shipping surveillance and aerial mining activities in the Yellow Sea, South China Sea, and the Formosa Straits. In 1954 he entered the Navy test pilot school at the Naval Air Test Center, Patuxent River, Md., and after completion of his training, was assigned to the electronics test division of the NATC. In this assignment Carpenter conducted flight-test projects with the A3D, F11F, and F9F and assisted in other flight-test programs. He then attended the Navy's general line school at Monterey, Calif., for 10 months and the Naval Air Intelligence School, Washington, D.C., for a further 8 months. In August 1958 he was assigned to the U.S.S. *Hornet*, antisubmarine aircraft carrier, as air intelligence officer. He has accumulated more than 2,800 flying hours, including 300 in jet aircraft.

His hobbies include skindiving, archery, and water skiing.

Leroy Gordon Cooper, Jr.

Leroy G. Cooper, Jr., a captain in the U.S. Air Force, was born March 6, 1927, in Shawnee, Okla. He is 5 feet 9½ inches tall and weighs 150 pounds. The 32-year-old astronaut has blue eyes and brown hair. He considers as his hometown Carbondale, Colo., where his parents, Col. and Mrs. Leroy G. Cooper, have a ranch. Colonel Cooper is retired from the Air Force. His wife is the former Trudy Olson of Seattle, Wash. The couple has two daughters, Camala K., 10, and Janita L., 9.

Cooper attended primary and secondary schools in Shawnee, and he attended the University of Hawaii 3 years. He received a degree in aeronautical engineering through the Air Force Institute of Technology at Wright-Patterson Air Force Base, Ohio, in August, 1956.

Cooper entered the Marine Corps in 1945 after his graduation from high school. He attended the Naval Academy Preparatory School and was a member of the Presidential Honor Guard in Washington immediately before his discharge in August 1946. While at the University of Hawaii, he received a commission in the Army. He transferred this commission to the Air Force and was recalled by that service for extended active duty in 1949 for flight training. After his training, he was assigned to the 86th Fighter Bomber Group in Munich, Germany, as an F–84, and later, an F–86 pilot. After his graduation from AFIT, he was assigned to the Air Force Experimental Flight Test School at Edwards Air Force Base, Calif. He was graduated from this school in April 1957, and was assigned duty in the Performance Engineering Branch of the Flight Test Division at Edwards. He conducted flight tests on experimental fighter aircraft. Cooper has 2,300 flying hours, including 1,400 in jets.

His hobbies are photography, riding, hunting, and fishing.

John Herschel Glenn, Jr.

John H. Glenn, Jr., a lieutenant colonel in the U.S. Marine Corps, was born July 18, 1921, in Cambridge, Ohio. He considers New Concord, Ohio, his permanent home. He attended primary and high schools in New Concord, and Muskingum College. His parents are Mr. and Mrs. John H. Glenn. The elder Glenn is a retired operator of a plumbing and heating business. Mrs. Glenn is the former Anna Margaret Castor, daughter of Dr. and Mrs. H. W. Castor. The elder Glenns and Castors all live on Bloomfield Road in New Concord. The Glenns have two children: John David, 13, and Carolyn Ann, 12. Glenn

also has a sister, Mrs. Jean Pinkston, of Cambridge. He is 5 feet 10½ inches tall, weighs 180 pounds and has green eyes and red hair.

Glenn entered the naval aviation cadet program in March, 1942. He was graduated and commissioned in the Marine Corps a year later. After advanced training, he joined Marine Fighter Squadron 155 and spent a year flying F4U fighters in the Marshall Islands. During his World War II service, he flew 59 combat missions. After the war, he was a member of Fighter Squadron 218 on North China patrol and had duty in Guam. From June 1948, to December 1950, he was an instructor in advance training at Corpus Christi, Tex. Glenn then attended Amphibious Warfare School at Quantico, Va. In Korea, he flew 63 missions with Marine Fighter Squadron 311 and 27 while an exchange pilot with the Air Force. In the last 9 days of fighting in Korea, he downed three Migs in combat along the Yalu River. After Korea, Glenn attended test pilot school at the Naval Air Test Center, Patuxent River, Md. After graduation, he was project officer on a number of aircraft, including the F8U, F8U–1 and F8U–P. Since November 1956, he has been assigned to the Fighter Design Branch of the Navy Bureau of Aeronautics in Washington.

Glenn has been awarded the Distinguished Flying Cross on five occasions and he holds the Air Medal with 18 clusters for his service during World War II and Korea. In July 1957, while project officer of the F8U, he set a transcontinental speed record from Los Angeles to New York, spanning the country in 3 hours 23 minutes. He has more than 5,000 hours of flying time, including 1,500 hours in jet aircraft. Glenn has been attending the University of Maryland during his Washington assignment.

The Glenn family hobbies are boating and water skiing.

Virgil Ivan Grissom

Virgil I. Grissom, a captain in the U.S. Air Force, was born April 3, 1926, in Mitchell, Ind. He is 5 feet 7 inches tall, weighs 155 pounds, and has brown eyes and brown hair. His parents, Mr. and Mrs. Dennis D. Grissom, live at 715 Baker Street, Mitchell. He has two brothers, Norman, of Mitchell, and Lowell, a sophomore at Indiana University, and a sister, Mrs. Joe Beavers of Baltimore. Mrs. Grissom is the former Betty L. Moore. Her father, Claude Moore, lives in Mitchell. Her mother is deceased. The Grissoms have two sons, Scott, 9, and Mark, 5.

Grissom attended primary and high schools in Mitchell and was graduated from Purdue University with a degree in mechanical engineering in 1950.

He first entered the Air Force in 1944 as an aviation cadet. He was discharged in November, 1945. He returned to aviation cadet training after his graduation from Purdue, and he received his wings in March 1951. .Grissom joined the 75th Fighter-Interceptor Squadron at Presque Isle, Maine, as an F–86 fighter pilot. He flew 100 combat missions in Korea in F–86's with the 334th Fighter Interceptor Squadron. He left Korea in June 1952 and became a pilot instructor at Bryan, Tex. In August 1955, he went to the Air Force Institute of Technology at Wright-Patterson Air Force Base, Ohio, to study aeronautical engineering. In October 1956 he attended test pilot school at Edwards Air Force Base, Calif., and returned to Wright-Patterson Air Force Base in May 1957, as a test pilot assigned to the Fighter Branch. He has flown more than 3,000 hours, over 2,000 in jets.

Grissom has been awarded the Distinguished Flying Cross and Air Medal with cluster.

His hobbies are hunting and fishing.

Walter Marty Schirra, Jr.

Walter M. Schirra (Shi-RAH) Jr., a lieutenant commander in the U.S. Navy, was born March 12, 1923, in Hackensack, N.J. The 36-year-old astronaut is 5 feet 10 inches tall, weighs 185 pounds, and has brown hair and brown eyes. His parents, Mr. and Mrs. Walter M. Schirra, reside in Honolulu, Hawaii, where the elder Schirra is a civil engineer with the Air Force. The senior Schirra was a World War I ace in the Army Air Corps. After the war, he and his wife barnstormed throughout the Eastern United States in a light plane. The astronaut's wife is the former Josephine C. Fraser of Seattle, Wash. The couple has two children: Walter III, 8, and Suzanne Karen, 1. Mrs. Schirra is the daughter of Mrs. James L. Holloway, wife of Admiral Holloway, who was com-

mander in chief of the northeastern Atlantic and Mediterranean area. Schirra also has a sister, Mrs. John H. Burhans, who lives in Patuxent River, Md.

Schirra attended primary and junior high schools in Oradell, N.J. He was graduated from Dwight Morrow High School, Englewood, N.J., in 1940, and attended Newark (N.J.) College of Engineering 1 year. He was graduated from the U.S. Naval Academy in 1945.

Schirra has had service on board the battle cruiser *Alaska*, the staff of the 7th Fleet, flight training at Pensacola, in a Navy fighter squadron (71), and as an exchange pilot with the 154th U.S. Air Force Fighter Bomber Squadron. He went with this squadron to Korea where he flew 90 combat missions in F–84E aircraft. He downed one Mig and has one probable Mig. He took part in development of the Sidewinder missile at China Lake, Calif. He was project pilot for the F7U–3 Cutlass and instructor pilot for the Cutlass and FJ3 Fury. He flew F3H–2N Demons as operations officer of Fighter Squadron 124 on board the carrier *Lexington* in the Pacific. He then attended Naval air safety officer school at the University of Southern California, and test pilot training at the Naval Air Test Center, Patuxent, Md. His last assignment was at Patuxent in suitability development work on the F4H. He has 3,000 hours of flying time, 1,700 hours in jets.

He has been awarded the Distinguished Flying Cross and two Air Medals for his Korean service.

Alan Bartlett Shepard, Jr.

Alan B. Shepard, Jr, a lieutenant commander in the U.S. Navy, was born November 18, 1923, in East Derry, N.H. The 35-year-old astronaut is 5 feet 11 inches tall, weighs 160 pounds and has blue eyes and brown hair. His parents, Col. and Mrs. Alan B. Shepard, live in East Derry where the elder Shepard, a retired Army of the United States officer, is an insurance broker. Shepard is married to the former Louise Brewer, of Kennett Square, Pa. The couple has two daughters, Juliana, 8, and Laura, 12. Shepard's sister, Mrs. Pauline S. Sherman, resides in Montclair, N.J.

Shepard attended primary school in East Derry and was graduated from Pinkerton School, Derry, N.H., in 1940. He studied 1 year at Admiral Farragut Academy, Toms River, N.J., and then entered the Naval Academy, Annapolis. He was graduated from Annapolis in 1944. He was graduated from the Naval War College, Newport, R.I., in 1958.

The astronaut saw service on the destroyer *Cosgrove*, in the Pacific during World War II. He then entered flying training at Corpus Christi, Tex., and Pensacola, Fla. He received his wings in March 1947. Subsequent service was in Fighter Squadron 42 at the Norfolk Naval Air Station and Jacksonville, Fla. He also spent several tours in the Mediterranean. Shepard went to test pilot school at Patuxent River, Md., and served two tours in flight test there. During this service, he took part in high altitude tests to obtain data on light at different altitudes and in a variety of air masses over the North American continent. He also took part in experiments in test and development of the Navy's inflight refueling system; carrier suitability trials of the F2H3 Banshee, and Navy trials of the first angled carrier deck. Between his flight test tours at Patuxent, Shepard was assigned to Fighter Squadron 193 at Moffett Field, Calif., a night fighter unit flying Banshee jets. He was operations officer of this squadron and made two tours with it to the western Pacific on board the carrier *Oriskany*. He has been engaged in the test of the F3H Demon, F8U Crusader, F4D Skyray, and F11F Tigercat. He was project test pilot on the F5D Skylancer. The last 5 months at Patuxent were spent as an instructor in the test pilot school. After his graduation from the Naval War College, Shepard joined the staff of the commander in chief, Atlantic Fleet, as aircraft readiness officer. He has 3,600 hours of flying time, 1,700 in jets.

Shepard's hobbies are golf, ice skating, and water skiing.

Donald Kent Slayton

Donald K. Slayton, a captain in the U.S. Air Force, was born March 1, 1924, in Sparta, Wis. The 35-year-old astronaut is 5 feet 10½ inches tall, weighs 160 pounds, and has blue eyes and brown hair. His parents, Mr. and Mrs. Charles S. Slayton, live in Sparta. A brother, Howard, and sister, Mrs. Lynda-

hel Hagen, also live in Sparta. Slayton's immediate family also includes a brother, Richard, of San Jose, Calif., another brother, Elwood, and two sisters, Mrs. Milton Madsen and Mrs. Harold Schluenz, all of Madison. His wife is the former Marjorie Lunney, daughter of Mr. and Mrs. George Lunney, of Los Angeles, Calif. The Slaytons have one son, Kent, 2.

Slayton attended primary and high schools in Sparta, graduating from Sparta High School in 1942. He entered the University of Minnesota in January 1947 and was graduated with a degree in aeronautical engineering in August 1949.

He entered the Air Force as an aviation cadet in 1942 and after instruction at Vernon, Tex., and Williams, Ariz., won his wings in April 1943. He flew 56 combat missions in B–25's in Europe with the 340th Bombardment Group (Medium). In mid-1944, he returned to this country as a B–25 instructor pilot at Columbia, S.C., and then served with a unit checking out pilots in the A–26. He joined with 319th Bombardment Group (Medium) and went to Okinawa in April 1945, where he flew seven combat missions over Japan. He was an instructor pilot in B–25 aircraft for about a year after the war. Following his graduation from the University of Minnesota, he was an aeronautical engineer with Boeing Aircraft Co. in Seattle, Wash., until recalled in early 1951 to active duty with the Air National Guard, in which he maintained membership during his student days at the University of Minnesota. On his recall, he was assigned to Minneapolis as maintenance flight test officer of an F–51 squadron. He then spent a year and a half at 12th Air Force Headquarters as technical inspector, and a like period as fighter pilot and maintenance officer with the 36th Fighter Day Wing in Bitburg, Germany. He returned to the United States in June of 1955 and attended the Air Force Flight Test Pilot School at Edwards Air Force Base, Calif. Since January 1956, he has been an experimental test pilot at Edwards, where he has flown all jet-fighter-type aircraft built for the Air Force. His last assignment was chief of Fighter Section A. He has 3,400 flying hours, 2,000 in jets.

Slayton holds the Air Medal with cluster.

His hobbies are hunting, fishing, shooting, archery, photography, and skiing.

NOTE.—Additional information can be found in House Committee on Science and Astronautics hearing, "Meeting With the Astronauts," of May 28, 1959 (No. 37).

PART VII

MANAGEMENT

The prime responsibility for Project Mercury management rests with the Administrator of the National Aeronautics and Space Administration. This responsibility is exercised with the advice and assistance of the Department of Defense, Advanced Reseach Projects Agency, through the Manned Satellite Panel, a joint NASA–ARPA steering committee. Advice on the role of the human pilot and all considerations involving him is provided by the NASA Special Committee on Life Sciences, composed of members drawn from the Army, Navy, Air Force, Atomic Energy Commission, Department of Health, Education, and Welfare, and from private life. The detailed direction of the project is the responsibility of the Space Task Group of the Goddard Space Flight Center. The Space Task Group is headed by the Assistant Director for Manned Space Flight of the Center. The organization structure for the management and direction of the project is shown in figure 16.

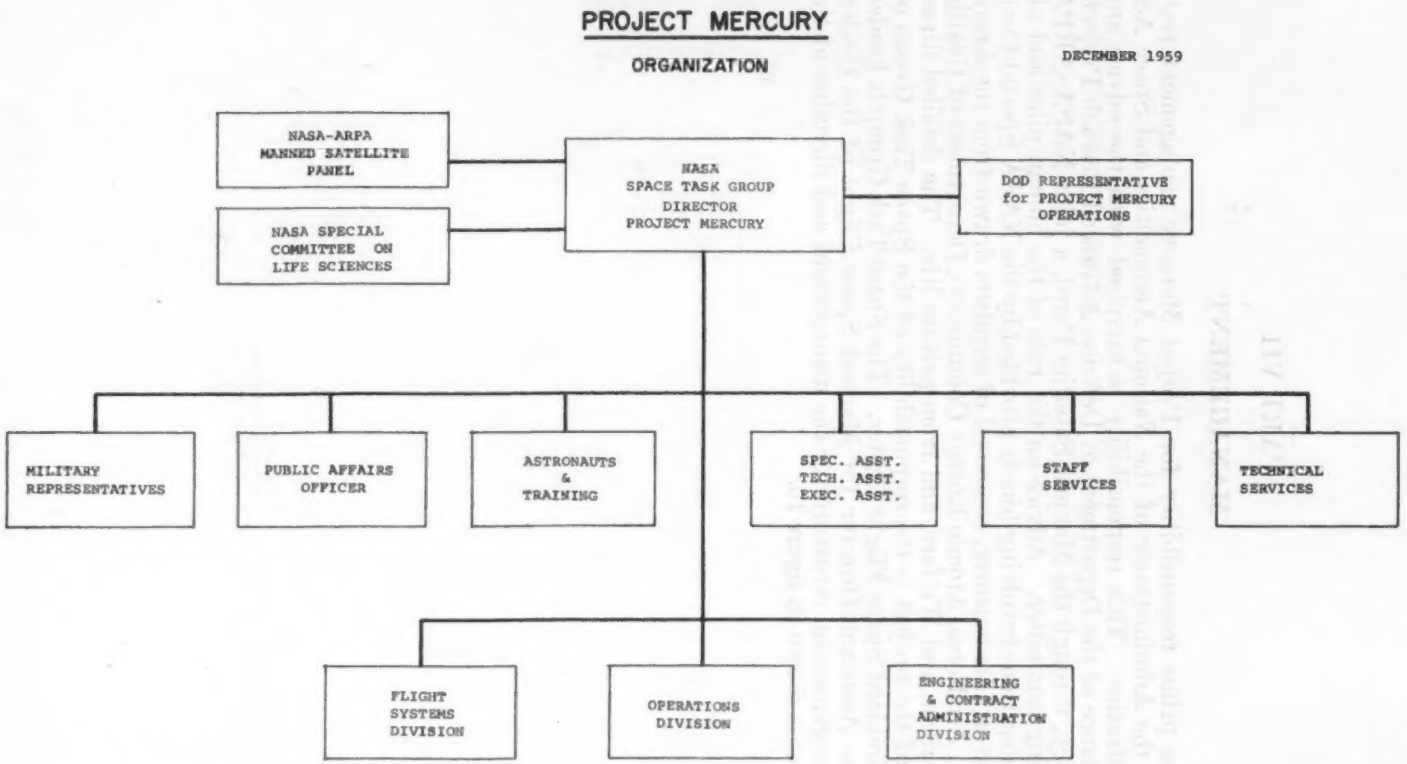
PROJECT MERCURY
ORGANIZATION
DECEMBER 1959
NASA-ARPA MANNED SATELLITE PANEL
NASA SPECIAL COMMITTEE ON LIFE SCIENCES
NASA SPACE TASK GROUP DIRECTOR PROJECT MERCURY
DOD REPRESENTATIVE for PROJECT MERCURY OPERATIONS
MILITARY REPRESENTATIVES
PUBLIC AFFAIRS OFFICER
ASTRONAUTS & TRAINING
SPEC. ASST. TECH. ASST. EXEC. ASST.
STAFF SERVICES
TECHNICAL SERVICES
FLIGHT SYSTEMS DIVISION
OPERATIONS DIVISION
ENGINEERING & CONTRACT ADMINISTRATION DIVISION

FIGURE 16

The contractors and organizations involved in Project Mercury are shown below. Abbreviations used are identified on page 64.

Project Mercury—Participation by contractors and Government agencies

Prime contractor or Government agency	NASA contract or order No.	Item	Subcontractor and item (or remarks)
NASA-Space Task Group		Project Mercury	
DOD, Major General Yates.		Mercury operations	
McDonnell Aircraft Corp.	NAS-5-59	Manned space capsule	Minneapolis-Honeywell: Automatic stabilization and control system. AiResearch: Environmental control system. Bell Aircraft Corp.. Hydrogen-peroxide control system. Food Machinery Corp.: Backup hydrogen-peroxide control jets. Eagle-Picher Co.: Batteries. Exide: Backup batteries. Collins Radio: Communications system. Cincinnati Testing Laboratories: Ablation heat shield. Brush Beryllium: Beryllium heat shield. Radioplane Division of Northrop: Landing system. Grand Central Rocket Co.: Escape rocket. Thiokol Chemical Corp.: Retro and posigrade rockets. Perkin-Elmer Co.: Periscope. Barnes Instrument Co.: Horizon scanner.
USAF-ARDC-BMD	HS-36 (amend ed)	Atlas booster and launch.	STL: Technical management. Convair Astronautics: Airframes and launch. Rocketdyne: Engines.
USA-AOMC-ABMA	HS-44	Redstone boosters and launch.	Chrysler Corp., Missile Division: Airframes. Rocketdyne: Engines.
NASA-Langley Research Center.		Range network	MIT, Lincoln Laboratories, Aeronutronics, RCA Service: Technical assistance. Western Electric: Prime range contract, project management. Bell Telephone Laboratories: Systems engineering, communications and control displays. IBM: Computer programing and simulation displays. Bendix Aviation Corp.: Radar installation, ground-air communications, telemetry, site display equipment. Burns & Roe, Inc.: Site facilities, construction, logistic support.
USAF-ARDC-CRC		Balloon program	Canceled.
USAF-ARDC-HAFB		Animal program	
USAF-ARDC-MTC		Launchings	
USAF-ARDC-AEDC		Wind-tunnel tests	
USAF-ARDC-ATC (Eglin).		Drogue-chute tests	Canceled.
USAF-ARDC-WADC		Human drop tests	
USAF-ARDC-WADC USAF-SAM		Astronaut training and consultation.	
USAF-ACIC		Maps and charts	
USAF-TAC		Airdrop support	
USN-AMAL USN-ACEL		Astronaut training and consultation.	
USN-BuAer		Pressure suits	B. F. Goodrich: Suits. WADC: Consultation. ACEL: Consultation and indoctrination.
USN-CNO		Recovery for Big Joe and Little Joe.	

Project Mercury—Participation by contractors and Government agencies—Con.

Prime contractor or Government agency	NASA contract or order No.	Item	Subcontractor and item (or remarks)
NASA-Langley Research Center.		Little Joe	North American Aviation: Airframe.
			Minneapolis-Honeywell: Automatic control system.
			Thiokol Chemical Corp.: Propulsion.
		Airdrops (parachute development).	
		Wind-tunnel tests	
		Rocket-model tests	
		Structures laboratory tests.	
		Noise tests	
		Shop support	
		Administrative and general housekeeping support.	
NASA-Ames Research Center.		Wind-tunnel tests	
		Ballistic range tests	
NASA-Flight Research Center.		Drogue-parachute tests.	
NASA-Lewis Research Center		Big Joe instrumentation, launching, and data reduction.	
		Altitude wind-tunnel tests.	
NASA-Wallops Station		Launchings	
		Airdrop support	

ABBREVIATIONS

NASA—National Aeronautics and Space Administration
DOD—Department of Defense
ARDC—Air Research and Development Command
BMD—Ballistic Missile Division
STL—Space Technology Laboratory
AOMC—Army Ordnance Missile Command
ABMA—Army Ballistic Missile Agency
MIT—Massachusetts Institute of Technology
RCA—Radio Corp. of America
IBM—International Business Machines
CRC—Cambridge Research Center
HAFB—Holloman Air Force Base
MTC—Missile Test Center
AEDC—Arnold Engineering Development Center
ATC—Armament Test Center
WADC—Wright Air Development Center
SAM—School of Aviation Medicine
ACIC—Aeronautical Chart and Information Center
TAC—Tactical Air Command
AMAL—Aviation Medical Acceleration Laboratory
ACEL—Air Crew Equipment Laboratory (Navy)
CNO—Chief of Naval Operations

It is noted in the contractor summary that there are a number of items on contract which are backup items. In the past, programs of great urgency have often been backed up or duplicated in order to insure their success.

In Project Mercury, however, the program management believes that a completely independent backup program would delay, rather than speed up, the ultimate accomplishment of the mission. This belief stems from the fact that two parallel programs would compete with each other for the necessary research and development support, manpower, and critical program items.

Consider, for example, the external configuration of the Mercury capsule. This configuration had to be finalized in a period of less than 6 months, through the use of a very extensive wind tunnel testing

program, airdrops of full-scale capsules, and rocket flight tests of small- and full-scale capsules. This phase of the program was completed on schedule only because no backup program of equally high priority was competing.

The approach used in carrying out Project Mercury, therefore, has been to back up only critical or questionable components of the system, and not the entire system. Typical examples are the heat shield, the batteries, and the reaction control system. At the beginning of the program, technical questions were raised in each of these areas; consequently, alternate systems, employing different technical approaches, are being procured in these instances.

Project Mercury management believes that this philosophy of backing up critical items rather than the entire program, represents not only a very sound approach from the point of view of program costs, but also will lead to the earliest possible achievement of manned orbital flight.

PART VIII

PROJECT MERCURY FUNDING

Funding of Project Mercury has varied in a pattern similar to that of other programs of national importance. The funding, as of the beginning of January 1960, is as follows:

"Research and development" appropriation

Fiscal year 1959:	
Initial allocation	$37,661,200
Current allocation	46,416,333
Fiscal year 1960:	
Initial allocation	90,116,000
Current allocation	74,962,000

In fiscal year 1959, the funds were increased to $48,494,233 to cover urgent and immediate program requirements. Subsequently, this amount was reduced by $200,000, which was reprogramed to "Supporting activities." The amount was then reduced by $1,850,000 as a result of the transfer of one Atlas booster to the lunar program. Finally, the figure was reduced by $27,900, which represented an uncommitted headquarters balance.

In fiscal year 1960, Public Law 86–12 authorized $20,750,000 for Project Mercury as a supplement to the fiscal year 1959 funds; however, only $16,675,000 was appropriated. This was added to the regular fiscal year 1960 appropriation, making an initial allocation of $90,116,000. The initial allocation was reduced by $15 million, which was transferred to the construction of the Mercury tracking net. The amount was further reduced by $634,000, the launch costs programed for the Atlas, which was transferred to the lunar program. $120,000 was transferred to "Supporting activities" for the Mercury program. Later, $100,000 was added to the program for controlled landing studies, and $500,000 added to cover other increased costs.

"Construction and equipment" appropriation

Fiscal year 1959:	
Initial allocation	0
Current allocation	$2,425,000
Fiscal year 1960:	
Initial allocation	13,995,000
Current allocation	28,995,000

The original report of fiscal year 1959 showed $7,020,000 allocated to "Construction and equipment." The 1959 supplemental, authorized by Congress under Public Law 86–12, totaled $4,595,000, but was actually in a fiscal year 1960 appropriation. Thus, the $4,595,000 is carried as a 1960 appropriation, and is part of the initial and current allocation.

The increase in the fiscal year 1960 funds for "Construction and equipment" of $15 million is the transfer from "Research and development" appropriation.

Current fund allocations are as follows:

Research and development	
Fiscal year 1959	$46,416,333
Fiscal year 1960	74,962,000
Total research and development	121,378,333
Construction and equipment	
Fiscal year 1959	2,425,000
Fiscal year 1960	28,995,000
Total construction and equipment	31,420,000
Grand total to date	152,798,333

Budget request to Congress for fiscal year 1961 is as follows:

Research and development	$107,750,000
Construction and equipment	15,000,000
Fiscal year 1961 total	122,750,000

In addition, NASA is requesting a supplement to their fiscal year 1960 budget as follows:

Research and development	$12,000,000
Construction and equipment	7,000,000
Total	19,000,000

Funds committed

McDonnell Aircraft Corp., prime contractor for capsule	$56,000,000
Western Electric, prime contractor for worldwide range network	34,000,000
AFBMD to Convair Astronautics and other contractors for Atlas boosters	27,900,000
ABMA Redstone boosters	15,550,000

The estimated completion cost of the project is $344,500,000.

PART IX

PROJECT MERCURY SCHEDULE

To date three Little Joe capsules have been fired from Wallops Island, Va. Two more are planned for 1960 with the last equipped with the production model of the McDonnell capsule. Additional firings of Little Joe may be scheduled.

Eight Redstone boosters scheduled for the test program will be fired from Cape Canaveral starting in mid-1960. The flights, using the McDonnell capsule, will start with unmanned instrumented capsules to be followed by manned flights.

One Atlas Big Joe was fired from Cape Canaveral to test reentry heating conditions using an ablation shield. Additional Atlas firings are scheduled to start in mid-1960. There will be a total of 13 Atlas firings. All remaining Atlas shots will use the McDonnell capsule. As mentioned previously in part V—Operational Concept, the Atlas firings will be both ballistic and orbital. Early orbital flights will be with and without primates. Following the successful completion of the program up to that point, the first manned orbital flight will take place. Although a target date has been established by NASA, the date has not been released nor will it be released until there is assurance that it will be met. However, the President in his budget message to Congress on January 18, 1960, stated: "It is expected that manned space flights will be attempted within the next 2 years. * * *"

McDonnell capsules on order now total 20. These are being delivered at a rate of two per month and will be used in all phases of the flight test program.

PART X

SUPPORT FROM MILITARY SERVICES

Following the decision of the President to assign the development of Project Mercury to the NASA the services were requested to provide a variety of supporting services. These are listed in some detail as follows:

Department of Defense

To avoid costly and time consuming duplication, the NASA, on August 4, 1959, in a letter to the Director of Defense Research and Engineering, Office of the Secretary of Defense, confirmed a number of informal requests that had been made between the NASA and elements of the Department of Defense. In this letter NASA confirmed its request for participation of the services in the Mercury tracking program and requested six SCR–584-type radars and one FPS–16 radar for installation at NASA sites.

On August 10, 1959, Maj. Gen. Donald N. Yates, USAF, was designated as Department of Defense representative for Project Mercury support operations. He is responsible for the direction and control of the Department of Defense facilities, forces and assets assigned for support of Project Mercury operations. The following memorandum from the Secretary of Defense designated General Yates as Department of Defense representative for Project Mercury support operations:

Memorandum for:
The Secretaries of the Military Departments
The Director of Defense Research and Engineering
The Chairman, Joint Chiefs of Staff
The Assistant Secretaries of Defense
The General Counsel
The Director, Advanced Research Projects Agency
The Assistants to the Secretary of Defense

Subject: Assignment of responsibility for Department of Defense support of Project Mercury

1. Maj. Gen. Donald N. Yates, USAF, is designated the Department of Defense representative for Project Mercury support operations. A naval deputy will be provided to assist in the recovery operation for Project Mercury. General Yates will continue his duties as commander, Atlantic Missile Range.

2. General Yates shall be responsible, through the Joint Chiefs of Staff, to the Secretary of Defense. He shall proceed with—

2.1 Preparation and submission for review and approval of overall plans and requirements in support of Project Mercury, including appropriate recommendations for their implementation. During development, these plans will be coordinated as appropriate with the Director of Defense Research and Engineering. Completed plans will be forwarded by General Yates to the Joint Chiefs of Staff. The Joint Chiefs of Staff will review these plans and provide comment and recommendations for final approval by the Secretary of Defense.

2.2 Direction and control of the Department of Defense facilities, forces, and assets assigned for support of Project Mercury.

2.3 Department of Defense performance of special missions assigned for support of Project Mercury.

3. The budgetary and public affairs aspects of the Department of Defense participation in Project Mercury will conform with the policies and procedures of the ASD (Comptroller) and ASD (Public Affairs).

4. It is desired that use of existing organizations be made. Accordingly, while General Yates is authorized such staff as may be required for the execution of his duties and as approved by the Secretary of Defense, it is expected that he will make maximum utilization of the existing agencies in the Department of Defense and military departments. He is authorized to have direct access to and communication with any elements of the military departments, unified and specified commands, and other Department of Defense agencies, and other appropriate departments and agencies of the Government performing functions related to those of Project Mercury over which he exercises direction and control.

U.S. Army

1. The Army will provide eight Redstone boosters to place Mercury capsules into ballistic trajectories. Boosters will be modified to be compatible with the Mercury capsule. The first few firings will be unmanned. Later firings will carry an astronaut as passenger. These will be the first missile-borne flights of the astronauts.

2. Army facilities at White Sands Missile Range will be available. This includes the use of a building and modification and use of a radar.

3. Army missile tracking facilities and worldwide communication system is available for use in Project Mercury.

4. Army will assist in recovery of Mercury vehicles launched by Redstone boosters.

5. Two firings using Army Jupiter boosters were planned, but the NASA directed that they be suspended. Preliminary layouts and drawings have been completed in the event they may be needed.

6. Army will provide Redstone launch facilities at Cape Canaveral at complex 56.

7. Army will conduct capsule component tests, overall Redstone missile and capsule system compatibility tests, simulated flight tests, prelaunch preparations, and launch.

U.S. Navy

1. The commander in chief, U.S. Atlantic Fleet (CINCLANTFLT) has been given responsibility for supporting Project Mercury during 1959 and has been requested to plan for support of the project during 1960. This responsibility during 1959 includes the development of recovery techniques, procedures, and hardware as well as providing ship and aircraft support for the solid rocket booster tests which are being conducted off Wallops Island, Va., and the Atlas-boosted test on the Atlantic Missile Range. The CINCLANTFLT plan for 1960 includes continued development of recovery techniques and providing ship and aircraft support of Project Mercury in the Atlantic Missile Range, the more extensive Mercury range, and for orbital operations. A typical Navy capsule retrieving system is shown in figure 17.

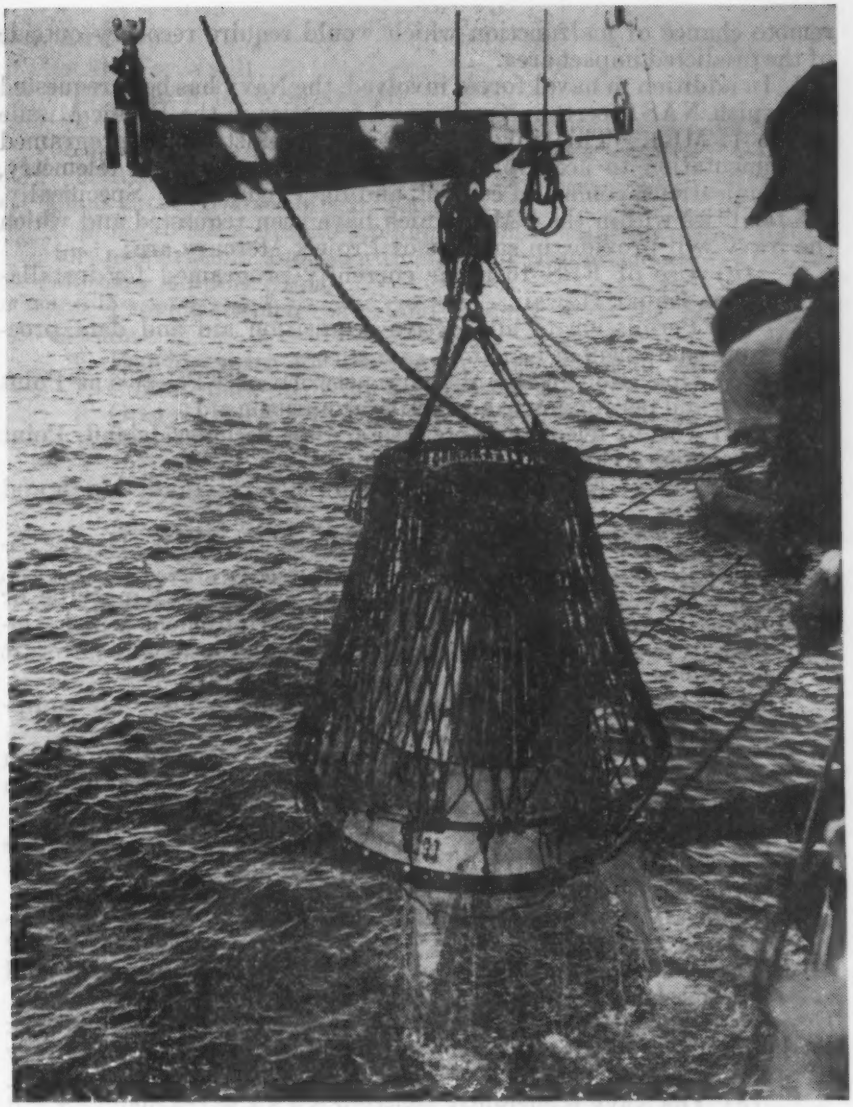

FIGURE 17.—*Retrieving capsule from sea using net rig (U.S. Navy recovery operation exercises).*

2. The commanding officer, Naval Ordnance Test Unit, Air Force Missile Test Center, Cape Canaveral, Fla., has been designated as naval deputy to the DOD representative for Project Mercury recovery operations and Navy support. In addition to such duties as may be assigned by the DOD representative, the naval deputy is responsible for the coordination of all naval support of Project Mercury. As the deputy for recovery, he will coordinate the preparation and execution of contingency plans for recovery on a global basis in the

remote chance of malfunction which would require recovery outside of the predicted impact area.

3. In addition to naval forces involved, the Navy has been requested to furnish NASA certain services and facilities in the Pacific Missile Range (PMR). This involves the use of existing or programed instrumentation to accomplish the function of tracking, telemetry, communications, command control, and data reduction. Specifically, the facilities within the PMR, which have been requested and which the Navy will provide, in support of Project Mercury are:

(*a*) Use of FPS–16 radar currently programed for installation on Kauai, Hawaii.

(*b*) Permission to add active acquisition aid and data processing equipment at Kauai.

(*c*) Operation in the Mercury network of FPS–16's at Point Mugu and permission to add active acquisition aid.

(*d*) Use of telemetry antennas at San Nicholas Island, Point Mugu, and Arguello.

(*e*) Use of FRW–2 command equipment at Point Mugu and Hawaii.

(*f*) Provide six surplus SCR–584 radars (WW II-type S-Band) for conversion to Verlort radar.

(*g*) Permission to locate a tracking station at Kingsville or Corpus Christi Naval Air Station. The equipment will be located in such a way as to cause no interference with aircraft operations.

(*h*) Use of building and power for telemetry and data equipment at Point Mugu.

(*i*) Use of the Navy Seabees for urgent work in connection with facilities and support of mobile equipment required on Canton Island.

(*j*) Use of PMR range-instrumentation ship for tracking, command, and telemetry off the coast of west Mexico.

4. Navy operational and development plan:

(*a*) Capsule recovery methods have been developed by CINCLANTFLT which utilize a basket-type recovery agent to lift the capsule from the water for use by destroyer-type ships, and a wire mesh rig suitable for helicopter pickup.

(*b*) Typical naval forces consist of destroyer-type ships, dock landing ships, helicopters used in surface search and recovery operations, and patrol-type aircraft used for air search operations.

(*c*) The Navy is currently assisting NASA in the planning and establishment of a mobile telemetry site at Canton Island and in the acquisition of two ships for instrumentation. Firm programs are underway to furnish the additional instrumentation facilities requested in the Pacific Missile Range.

5. Four major activities under the Bureau of Medicine and Surgery are engaged in bioastronautics programs associated with Project Mercury. These activities are the Aviation Medical Acceleration Laboratory, Johnsville, Pa., the Naval Medical Research Institute, Bethesda, Md., the Naval School of Aviation Medicine, Pensacola, Fla., and the Air Crew Equipment Laboratory, Johnsville, Pa.

U.S. Air Force

The Air Force will:

1. Provide 13 Atlas boosters.
2. Provide booster launch officials and crews to assist the NASA on ballistic and orbital launches of the Atlas booster.
3. Assist in the preparation of Mercury launch operations plans at the Atlantic Missile Range.
4. Establish a Mercury planning office with the responsibility for preparation and coordination of Department of Defense Mercury support plans.
5. Provide launch pads and hangar area for booster and capsule.
6. Provide space for the NASA data collection equipment.
7. Collect data utilizing Air Force and NASA equipment.
8. Operate the NASA equipment for data collection at stations in Africa and Atlantic and Indian Ocean areas.
9. Provide operational coordination for the NASA-operated station at Bermuda.
10. Assist in the planning for Mercury data collection by the Air Force facilities in the Pacific area.
11. Provide assistance in recovery planning.
12. Provide rescue service as outlined in the Mercury recovery plan.
13. Provide on-call or scheduled passenger and cargo-carrier services in accordance with established procedures.
14. Provide animals for phases of the biomedical test program.
15. Provide wind tunnel test facilities at the Arnold Engineering Development Center, Tenn.
16. Provide astronaut training and consultation at the Air Force School of Aviation Medicine, San Antonio, Tex., and the Wright Air Development Center, Ohio.
17. Provide maps and charts for the navigation phase of the Mercury program.
18. Provide aircraft for test drops of the Mercury capsule.
19. Provide aircraft for proficiency crew training of the astronauts.

PART XI

CONCLUSIONS

1. The Mercury program, as planned, is progressing satisfactorily. However there has already been some program slippage from the original plan, and the most optimistic schedule for the attainment of orbital flight is likely to show a slippage of many more months. In official announcements, NASA has wisely refused to commit itself to any time schedule which might bring the temptation to launch a man before the level of development fully justified this step.

2. The program has been awarded a DX rating. This is, therefore, one of several programs with the highest national priority. However, a high priority rating does not of itself guarantee that funds, resources, and program approach will represent a maximum effort to attain success at the earliest date.

3. At the present time, Mercury is our only program funded and actually underway for putting man into orbit. Considering the number of challenging new techniques which must be mastered to make space flight a success, there is question whether the national interest is best served by a single approach to this problem. The only provision against the hazards of "all eggs in one basket" has been to have backup contracts on those components for Mercury which are most likely to provide trouble.

4. There are a number of very promising alternative approaches to putting man in space. By setting a limit on testing these concepts through exclusive adoption of the Mercury approach, the Nation is risking the loss of extremely valuable development time. The country cannot support a large number of approaches in competition with all the other demands on fiscal and personnel resources. But at the same time the failure to develop in parallel at least one other man-in-space program could prove to be a costly mistake.

5. Certain decisions in connection with Mercury have, in the past, been criticized. Briefly they involve the following:

(*a*) The program was delayed initially by an inability to settle the question of management jurisdiction. The program as ultimately approved in October 1958 was virtually the one already proposed by the Department of Defense in May 1958.

(*b*) There was criticism over the selection of the McDonnell Aircraft Co. as the contractor for the manned capsule. The committee is not in a position to pass judgment on the wisdom of this selection, and, at this stage, it would serve no useful purpose to do so.

(*c*) There was criticism over the original insistence by NASA for using a heat sink reentry configuration. This problem has now been solved by the adoption of an ablation-type heat shield.

(*d*) There was criticism that the Atlas missile was not going to prove reliable enough to use a manned system. The progress

of Atlas testing seems to have answered this objection as indicated by the last 15 firings, all of which have been successful.

(*e*) Some of the remaining criticisms cannot be answered as long as the present concept of a single approach with only partial backup is followed.

6. Overall, the committee commends the dedication, the ingenuity, and the orderly approach being demonstrated by the many people in NASA, the armed services, the private laboratories, and industry in contributing to Project Mercury. The committee has reported earlier on its excellent impression of the seven astronauts, and desires that the best this country can give be afforded these men to make their mission a success. If there is an element of criticism in this report, it is not of what is being done or of the people involved, but rather that we are not doing more with other programs dedicated to the broader end of attaining a useful man-in-space capability.

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86TH CONGRESS } HOUSE OF REPRESENTATIVES { REPORT
2d Session } { No. 1229

REVISING THE BOUNDARIES OF THE ZION NATIONAL PARK, UTAH

JANUARY 27, 1960.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

Mrs. PFOST, from the Committee on Interior and Insular Affairs, submitted the following

REPORT

[To accompany S. 713]

The Committee on Interior and Insular Affairs, to whom was referred the bill (S. 713) to revise the boundaries of the Zion National Park in the State of Utah, and for other purposes, having considered the same, report favorably thereon without amendment and recommend that the bill do pass.

LEGISLATION CONSIDERED

The committee considered S. 713 and H.R. 4356, by Representative Dixon of Utah, which is identical to S. 713 as it was introduced.

PURPOSE

S. 713 would authorize certain boundary revisions at Zion National Park in Utah. The revisions would add approximately 3,420 acres of land to the park and would facilitate the preservation, protection, and administration of certain outstanding scenic and geologic features and make them more accessible to the public.

NEED

The details of the proposed boundary adjustments, with an indication of the need for each, are contained in the report of the Department of the Interior, which is made a part of this report.

The Department of the Interior held public hearings in 1957 at Cedar City, Utah, at which time the public reaction to the proposed

boundary adjustments was favorable. The proposal is favored by local governmental officials. No objection to the proposal has been received by the committee.

COST

The Department of the Interior reports that about 1,416 acres of the land involved in the additions that would be authorized by S. 713 are already owned by the United States. Lands to be acquired from other owners total about 2,004 acres and have an estimated value of about $60,000.

DEPARTMENT RECOMMENDATION

The Department of the Interior recommended the enactment of S. 713, as introduced, with two minor perfecting amendments which were incorporated in the bill by the Senate. The Department report follows:

U.S. DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., June 15, 1959.

Hon. JAMES E. MURRAY,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

DEAR SENATOR MURRAY: Your committee has requested a report on S. 713, a bill to revise the boundaries of the Zion National Park in the State of Utah, and for other purposes.

We recommend the enactment of S. 713, and further suggest two minor perfecting amendments.

This bill would authorize the addition of approximately 3,420 acres of land lying near to the south entrance of the park, and certain boundary revisions.

The Zion National Park contains a grandeur of colorful canyons and mesa scenery that ranks high among the superlative scenic areas in the world. It is noted for its deep, narrow canyons, sheer rock walls, and impressive individual rock masses such as the Great White Throne. The lavish display of color found there sets this area apart from all similar geological phenomena perhaps more than any other single feature. Moreover, there are few places that possess such superb examples of faulting, upheavals, settlements, warpings, volcanism, and other erosional manifestations. The plants and animals of the Zion National Park demonstrate many phases of environmental development that show the influence of these geological processes.

The boundary adjustments proposed by S. 713 would facilitate the preservation, protection, and administration of these spectacular geological features and make them more accessible to visitors.

One revision proposed involves a relocation of the northeast boundary of the park which would result in the addition of about 1,480 acres of land. The addition of these lands would make possible the preservation of a notable terraced lava field and would provide lands needed for an access road to the Lava Point Fire Lookout Station. Kolob Creek, thereby, would become the natural boundary of a portion of the park in this area and would also be available as an economical source of water for the nearby ranger station.

The bill would further authorize the addition of about 1,260 acres of land lying near the south entrance to the park. Some of this land, lying east of the Virgin River, is suitable for development as a residential and utility area, if future studies justify removal of the present development from the scenic Oak Creek Canyon. If not utilized for this purpose, it would be available for expansion of the adjoining campground. Other lands at the south entrance are needed as a protective area for the south face of the West Temple which is a feature already in the park.

A third boundary adjustment involves the addition of about 640 acres on the west side of the park. These lands provide the most feasible route for a proposed road that would give access to significant features in this section of the park. The remaining proposed boundary revision, in the northwest corner of the park, involves the exclusion of approximately 4½ acres of land to facilitate the realinement of U.S. Highway 91 and the inclusion of about 40 acres lying east of such relocated highway. Thereby, the easterly right-of-way line of U.S. Highway 91 would become the boundary of the park throughout section 29, township 38 south, range 12 west. Under authority contained in the bill, the Secretary would be authorized to convey to the Utah State Road Commission the lands required as a right-of-way for U.S. Highway 91, in exchange for which the State of Utah would agree to construct an interchange that would provide vehicular access between that highway and the Zion National Park.

Hearings were held in Cedar City, Utah, on June 12, 1957, at which time the boundary adjustment proposals planned for the Zion National Park were presented, along with those for the Arches and Capitol Reef National Monuments. The public reaction to these proposals was favorable.

Approximately 1,416 acres of the land area included in the proposed additions are in Federal ownership and the remainder, about 2,004 acres, is privately owned. It has been estimated that the cost of acquisition of the privately owned lands within the proposed additions would be about $60,000.

We would suggest two minor perfecting amendments, one on page 2, line 16, where the word "end" be changed to "and", and on page 2, line 22, where the word "an" be changed to "and".

The Bureau of the Budget has advised that there is no objection to the submission of this report to your committee.

Sincerely yours,

ROGER ERNST,
Assistant Secretary of the Interior.

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D.C., June 8, 1959.

Hon. JAMES E. MURRAY,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

MY DEAR MR. CHAIRMAN: This is in response to your request for the views of the Bureau of the Budget with respect to S. 713, a bill to revise the boundaries of the Zion National Park in the State of Utah, and for other purposes.

The report which the Secretary of the Interior is submitting on this bill sets forth the reasons for the desired boundary revisions, and other details concerning the proposed land transfer and acquisition.

This Bureau concurs in the views expressed in that report and accordingly would not object to the enactment of S. 713.

Sincerely yours,

PHILLIP S. HUGHES,
Assistant Director for Legislative Reference.

COMMITTEE RECOMMENDATION

The Committee on Interior and Insular Affairs recommends the enactment of S. 713 without amendment.

O